JPRS 78985

16 September 1981

USSR Report

MATERIALS SCIENCE AND METALLURGY

No. 76

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Indexes to this report (by keyword, author, personal names, title and series) are available through Bell & Howell, Old Mansfield Road, Wooster, Ohio, 44691.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

Soviet books and journal articles displaying a copyright notice are reproduced and sold by NTIS with permission of the copyright agency of the Soviet Union. Permission for further reproduction must be obtained from copyright owner.

JPRS 78985

16 September 1981

USSR REPORT

Materials Science and Metallurgy

No. 76

Contents

ALUMINUM AND ITS ALLOYS

High-Strength Aluminum Powder Alloys.............................. 1

Heat-Resistant Aluminum Powder Alloys............................. 1

Preparing Secondary Aluminum Alloys From Chips at Machine Building Plants... 2

Determining Fracture Toughness of High Strength Aluminum Alloy Based on Stress Intensity Factor at the Tip of a Crack at the Moment it Starts To Propagate............................ 3

COMPOSITE MATERIALS

Heat Conductivity of Powdered Composite Materials Based on Zirconium Nitride, Molybdenum and Aluminum Oxide................. 4

High-Density Composite Material Based on 10R6M5 High-Speed Steel and Titanium Carbide.. 4

Liquid Phase Migration in a Sintered Composite Consisting of a Refractory Phase and Liquid Metal................................ 5

FERROUS METALLURGY

Soviet Ferrous Metallurgy Production Structure Forecasting......... 6

Oskol Electrometallurgical Combine................................. 23

Ukrainian Ferrous Metallurgy Goals in 11th Five-Year Plan.......... 26

FOUNDRY

Producing Castings From Aluminum Alloys by Immersion of the Chill Mold in the Melt.. 37

MECHANICAL PROPERTIES

Predicting Influence of Structural Factors on Mechanical Properties of High-Temperature Alloys........................... 38

POWDER METALLURGY

Corrosion Resistance of Porous Fiber Materials.......................... 39

Phase Composition and Properties of Sintered Specimens Pressed From Powdered Mixture of Nickel and Titanium.......................... 39

Optimizing Process of Hot Pressing of VK6 Hard Alloy................ 40

Sodium-Thermal Production of Titanium Powders of Chlorides......... 40

Investigating Breakdown of EP-701P Refractory Alloy by Thermal Microscopy Method.. 41

Energy of Interlayer Interaction and Relative Stability of Different Crystalline Modifications of Graphite-Like Boron Nitride.. 42

Abrasiveness of Titanium Carbide and Titanium Carbonitride......... 42

TITANIUM

Increasing Homogeneity of a Titanium Sponge Block in Terms of Chlorine Impurity.. 43

Kinetics of Decomposition of the Metastable β-Phase in VT15 Titanium Alloy During Age Hardening.............................. 44

MISCELLANEOUS

Transport Problems in Open-Pit Ore-Mining Operations............... 45

Seeking Comprehensive Utilization of Raw Materials in Metallurgical Industry.. 49

Metals Input of Societal Production.................................... 61

Laser Treatment of Metals.. 77

Specialization Urged in Making Spare Parts for Metallurgical Machinery.. 79

Norm Setting of Internal Working Capital at Mining Enterprises..... 82

Changes in Specific Power of an Electron Beam During Formation of a Hole.. 88

Applying Electric-Spark Alloying To Change Optical Properties of Metal Surfaces.. 88

Kinetics of Deformation and Destruction of Some Electroplated Coatings by Friction.. 89

Problem of Forces in Microcutting of Heat Resistant and Titanium Alloys.. 90

Possibility of Determining Crack Resistance Characteristics With Final Formation of a Notch by Pressing......................... 90

Selecting Conditions for Determining Effective Surface Energy of Fracture of Brittle Materials.................................. 91

Residual Stress in Hard Alloys of the VK Group After Diamond Grinding.. 91

Some Problems of Deformability of Diamond-Carrying Layer of Disks During Shaping and Straightening............................ 92

Limiting State Criteria of Certain Steels Under Complex Stress Conditions at Room Temperature and Elevated Temperatures......... 93

Structural Alloy Based on Intermetallide Ni_3Al..................... 93

New Materials and Technical Progress................................ 94

Influence of Critical Stage of Polygonization on Ductility Characteristics of Tungsten in High Temperature Mechanical Tests... 95

ALUMINUM AND ITS ALLOYS

UDC 669.715:621.762

HIGH-STRENGTH ALUMINUM POWDER ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 81 pp 30-32

KRIVENKO, R. A., KAUFMAN, E. Ya., BOLOTOVA, N. Ye. and VOLODINA, R. P., All-Union Scientific Research Institute of Aviation Materials

[Abstract] An investigation is made of the mechanical properties of PV90 high-strength aluminum powder alloy based on the Al-Zn-Mg-Cu system. It is found that parts made from this material have high dimensional stability at room temperature and down to -60°C. The change in length of specimens is independent of heat treatment, and does not exceed 1-2 μm over a ten-month period with cooling to -60° ten times. These alloys are highly machinable and take a high polish. Optical mirrors machined from the material have a surface roughness of 0.032 μm and accuracy of 2.5 interference rings. Reflectivity is as good as a coated standard. Flatness and reflectivity are unchanged after holding for ten days at 98% relative humidity and -40°C. The fatigue limit of notched specimens is improved by 25% by increasing the temperature of the quenching bath from 20 to 35°C in heat treatment. Figures 1; references 5: all Russian.
[133-6610]

UDC 669.715:621.762

HEAT-RESISTANT ALUMINUM POWDER ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 81 pp 32-34

MATVEYEV, B. I., STEPANOVA, M. G., BALDIN, V. D. and RODCHENKOV, B. S., All-Union Scientific Research Institute of Aviation Materials

[Abstract] The properties of pressed structural shapes made of SAP-1 and SAP-2 aluminum powder alloys are studied by examination of fractures. Mechanical properties are determined on standard specimens 10 mm in diameter in the

longitudinal direction at 20, 250, 350 and 500°C. The structure of the specimens was studied on macrotemplets cut in the longitudinal and transverse directions, and also on microsections. It was found that strength characteristics of both alloys decrease monotonically with increasing temperature, while the behavior of relative longitudinal extension and lateral contraction shows a maximum at 350°C. Pressed bars of the alloy with a laminar fracture have lower strength properties than analogous bars with fine-grained fracture. An investigation of the influence of pressure on structure of the alloy in hydrostatic briquetting shows that this forming technique stabilizes the structure and improves the strength characteristics of the alloy. SAP alloys and grade 01419 aluminum powder alloy can be used as corrosion-resistant construction materials for operation in air at temperatures up to 300°C. These alloys are being used in the supporting structures for pipes in 1500 MW RBMK reactors. Figures 3; references 4: all Russian.
[133-6610]

UDC: 621.74:669.715

PREPARING SECONDARY ALUMINUM ALLOYS FROM CHIPS AT MACHINE BUILDING PLANTS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 1, Jan 81 pp 14-15

KIMSTACH, G. M., candidate of technical sciences (Rybinsk Institute of Aviation Technology)

[Abstract] Chips can be prepared for remelting with a dryer, magnetic separator and screen. High purity with respect to nonmetallic inclusions and gases is achieved by remelting the chips in induction crucible furnaces. The melt is isolated from the atmosphere and continually purified, then refined. Photomicrographs of the grain structure of the metals produced are presented. Refined secondary alloys can represent up to 6 to 8% of the total balance of metal used in casting shops. Figures 2; references 2: both Russian.
[130-6508]

UDC: 669.71:620.172.2

DETERMINING FRACTURE TOUGHNESS OF HIGH STRENGTH ALUMINUM ALLOY BASED ON STRESS INTENSITY FACTOR AT THE TIP OF A CRACK AT THE MOMENT IT STARTS TO PROPAGATE

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 46, No 10, Oct 80
(manuscript received 10 Jul 79) pp 949-951

SMOLENTSEV, V. I. and LEBEDEV, G. D.

[Abstract] Studies of rolled plates of D16 alloy manufactured in various ways show that cracks do not start propagating at the same stress level in specimens produced by different methods. Although previous studies have indicated that one of the most fundamental characteristics of a material is the parameter defining the capability of the material to resist starting of propagation of a crack, further studies indicate that this is not so. The purpose of the present work is to improve the method of determining the fracture toughness of semifinished goods of high strength aluminum alloys based on the stress intensity factor at the tip of a crack at the moment it starts propagating. The essence of the method is simultaneous recording of diagrams of load versus displacement and of the amplitude of the acoustical signal. The method is judged successful. At relatively high values of stress (around 40 MPa/m^2), the crack propagation starting stress is 32.7-36.2 MPa/m^2. Figures 5; references 3: 2 Russian, 1 Western.
[132-6508]

COMPOSITE MATERIALS

UDC: 621.762.5:669.018.95:669.2/8

HEAT CONDUCTIVITY OF POWDERED COMPOSITE MATERIALS BASED ON ZIRCONIUM NITRIDE, MOLYBDENUM AND ALUMINUM OXIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 81
(manuscript received after revision 30 Nov 80) pp 58-62

YECOROV, F. F. and GORYACHEV, Yu. M., Institute of Problems of Material Science, Ukrainian Academy of Sciences

[Abstract] Heat conductivity of powdered composite materials based on ZrN-Al_2O_3, Al_2O_3-Mo and Mo-ZrN was studied as a function of temperature and concentration. Specimens measuring 5 x 5 x 16 mm were tested in a medium of pure argon. Microstructural analysis revealed that all of the specimens studied had two-phase structure. Porosity did not exceed 3-4%. The variation of heat conductivity with temperature was not determined by simply adding the heat conductivities of the components, but rather depended on the interaction between them during sintering, which results in the formation of new phases or solid solutions. The variation of heat conductivity as a function of concentration is additive at both room temperature and elevated temperatures when there is little interaction between the components during sintering, differing from the variation when there is greater interaction between components. Figures 4; references 12: all Russian. [127-6508]

UDC 620.22:621.762.5+621.762.4

HIGH-DENSITY COMPOSITE MATERIAL BASED ON 10R6M5 HIGH-SPEED STEEL AND TITANIUM CARBIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 81
(manuscript received 14 Jan 81) pp 65-68

OLENINA, N. S., GORYUSHINA, M. N., GAVRIKOV, N. N. and SERGAZIN, T. Sh., Moscow

[Abstract] The effect of titanium carbide on some properties of high-speed 10R6M5 powder steel was investigated and the production conditions that ensure a high-density material by cold forming and sintering methods were determined.

A high-density sintered billet can be produced from a pulverized powder of high-speed 10R6M5 steel hardened with 5 percent titanium carbide by cold forming and sintering methods. The density and structural homogeneity of the sintered billet can be increased by subsequent forging. Hardness of HRC 70 was achieved after standard heat treatment. Figures 4; references 2: both Russian.
[137-6521]

UDC: 532.68

LIQUID PHASE MIGRATION IN A SINTERED COMPOSITE CONSISTING OF A REFRACTORY PHASE AND LIQUID METAL

Kiev SVERKHTVERDYYE MATERIALY in Russian No 1 (10), Jan-Feb 81
(manuscript received 3 Dec 79) pp 17-24

LISOVSKIY, A. F., Institute of Superhard Materials, Ukrainian Academy of Sciences

[Abstract] The motive forces of the convective mass transfer of liquid metals in sintered composites have been little studied and there is no phenomenologic description of the process. The present article presents an analysis of these problems. Equations are derived for the pressure created by the combined influence of capillary forces and the pressure arising as a result of recrystallization of particles in the area consisting exclusively of solid phase particles. The studies establish that the flow of metal melt is proportional to the pressure gradient of migration. The vector of the flow coincides with the pressure gradient vector. The process of migration of the liquid phase in sintered composites consisting of a refractory phase plus a liquid metal is described by a second order nonlinear differential equation in partial derivatives. Figures 5; references 11: 10 Russian, 1 Western.
[131-6508]

FERROUS METALLURGY

SOVIET FERROUS METALLURGY PRODUCTION STRUCTURE FORECASTING

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 17, No 3, May-Jun 81 (manuscript received 25 Nov 80) pp 562-574

[Article by A.S. Smyshlyayev and V.D. Pavlenko, Moscow: "Forecasting the Production Structure in the USSR's Ferrous Metallurgy Industry"]

[Text] Mathematical economic modeling of the development of the ferrous metallurgy industry embraces various aspects of reproduction--the processes of transforming production resource input into concrete product output, speeding technical progress, modifying the structure of production and the like. Estimates at the industrial level in the development of a national economic forecast can also assist in solving such specific problems as estimating the demand for production resources, determining requirements for technical progress, etc. Orientation of an industry model toward the implementation of a specific forecasting task predetermines the set of variables included in the model as well as the structure of interaction between them. Interrelationship of the industry forecast with calculations at a higher level is accomplished through such indicators as product output, total number of employees, capital investment, most important kinds of physical input and characteristics of the distribution of products produced.

At the present time a number of standard industry models are known which make it possible to make optimization analyses of the specialization and distribution of enterprises of the ferrous metallurgy industry, as well as of its key production processes [1, 2]. In this article a highly integrated (for the industry level) applied model is discussed, which is used in medium-term forecasting calculations for estimating production dynamics and the production structure in the USSR's ferrous metallurgy industry.

The estimate of the total demand for the industry's products is determined by the rates of growth of the major metal-consuming industries--machine building and construction. Such calculations can be performed, for example, by means of a traditional interindustrial balance model or of a model of interindustrial interaction [3]. The resources necessary for development of the industry can be revealed by means of a system of production functions or technical and economic estimates [4, 5]. Numerous economic and technical and economic studies whose results can be taken into account in specifying individual blocks of the model [6] are devoted to estimating the potential demand for metal products in a medium- and longterm forecast. Global macroeconomic indicators are used for estimating the future dynamics of metal products in a number of studies (forecast of the European Coal and Oil Association, of the International Institute of Ferrous Metals, and the like [7]). Integrated estimates of the structure of production are discussed considerably less frequently.

An economic statistical analysis of the volume and structural characteristics of the development of the ferrous metallurgy industry testifies to the fact that the direct transfer of the methodological approaches used in the interindustrial interaction model to the industry level is unsound, since with the overall variation of statistical indicators over time relatively stable interrelationships between input elements and the output of individual kinds of products are present. The point is that at this level processes for the substitution of some kinds of raw material with others are generally expressed relatively slightly even in the scope of a 10- to 15-year period, especially in an industry so structured and so slow to change on the technological plane as ferrous metallurgy is, and the substitution of one technology with another (with a more economical input structure) is also distributed over time.* In this case the dominant role is played by processes of supplementing some kinds of raw material with others. Only in the area of energy consumption is it possible to assign preference to an analysis of the interchangeability effect upon condition of the equivalence not only of the heat engineering but also of the technological value of energy media.

The segregation of "pure" technological subindustries in modeling is explained not only by statistical requirements for the comparability of indicators over time, but also by the very orientation of the model of the ferrous metallurgy industry toward participation in calculations for a full-scale-cost interindustrial model.** Forecasting of the industry's indicators is accomplished on the basis of technological ties between subindustries and products, by means of estimating the parameters of a system of regression equations of the recursion type. In this case if a single product is produced an equation for the demand for it is included in the model and the costs of producing it are estimated. In those subindustries in which the range of products is extensive, it is necessary to reflect the input for each type, taking into account general limitations on production resources. Limitations can be constructed by means of a special kind of production function in which the shortage of some raw material results in a reduction in product output, in the potential demand's exceeding it. In macroeconomic models this situation results in the sped-up substitution of raw material resources in short supply by means of other materials because of a variety of production processes and technologies. The possibilities of substitution are considerably fewer at the industry level of modeling the structure of the ferrous metallurgy industry.

---

*For example, the changeover from the open-hearth to the converter method of making steel in various countries occupied a period of 10 to 20 years.

**By the combined "ferrous metallurgy" industry is understood a combination of technological subindustries divided into independent units in the existing organizational structure. This interpretation of subindustries does not contradict considering them as a group of enterprises united among themselves according to the principle of the production of a uniform product.

Let us define the exceptional influence of production demand on production dynamics as the result of the strictness of the relationship. The latter has taken place historically as the effective consequence of the economic division of labor. The quantitative characteristics of this interrelationship themselves can change over time under the influence of technical progress, but other substantial factors are nevertheless felt to a minimum degree. Therefore, relatively simple econometric equations are used in the description. With modification of the strict relationship as the result of an increase in the supply of an effectively substituting type of resource, a new technological method of production is practically always formed, which must be reflected independently in the model. Here the econometric description becomes more complicated only at the integrated level, i.e., without the isolation of this method.

Such variables as stockpiles of resources also take part in the model. This refers primarily to the stock of metal, since a model of the scrap formation process, and consequently an estimate of the potential source for a growth in production, occupies an important place in longterm forecasts. In addition, gross output and a number of technical and economic indicators are calculated. The description of the model includes variables which, in keeping with the classification of the USSR TsSU [Central Statistical Board], characterize the following types of production [8]: mining, concentrating, sintering and pelletizing ore of ferrous metals; the production of pig iron, steel, rolled stock, pipes and products for subsequent processing; electric furnace ferroalloy production; coking byproduct production; production of refractories; secondary processing of ferrous metals; and the production of metal products for industrial purposes. The production of nonmetalliferous raw material for ferrous metallurgy is not discussed, on account of a lack of information. On the whole the model consists of eight blocks (cf. fig 1).

The interrelationships between the variables included in the econometric model reflect possibilities of delimiting input indicators both inside and outside of it. The exogenous estimation of individual variables is assumed. For example, with a given demand for pipes and rolled stock the dynamics for the production of steel will be determined only by the structure of their distribution. About 80 percent of the final output of metal products [9, p 173], the major portion of which goes to machine building and metalworking, is due to pipes and rolled stock.

In the model's system of equations the direction of effects is opposite technological flows, since the structure of production is forecast as a function of the demand for products. The quality characteristics of the development of the domestic metallurgy industry are derivatives in establishment of the technological structure of individual production processes. A change in the share of a specific technology and the revelation of the dominant one among them makes it possible to describe in the model longterm trends in technical progress. This approach proves to be fruitful in taking into account balance identities in the procedure for estimating the model's parameters. Alteration of the structure of the production of products on account of nonuniform development of various technological methods is characteristic of the steelmaking process and the production of coke and prepared raw iron ore, whereas the structure of the manufacture of cast iron and of casting ferrous metals is relatively invariant to a change in the structure of the final output.

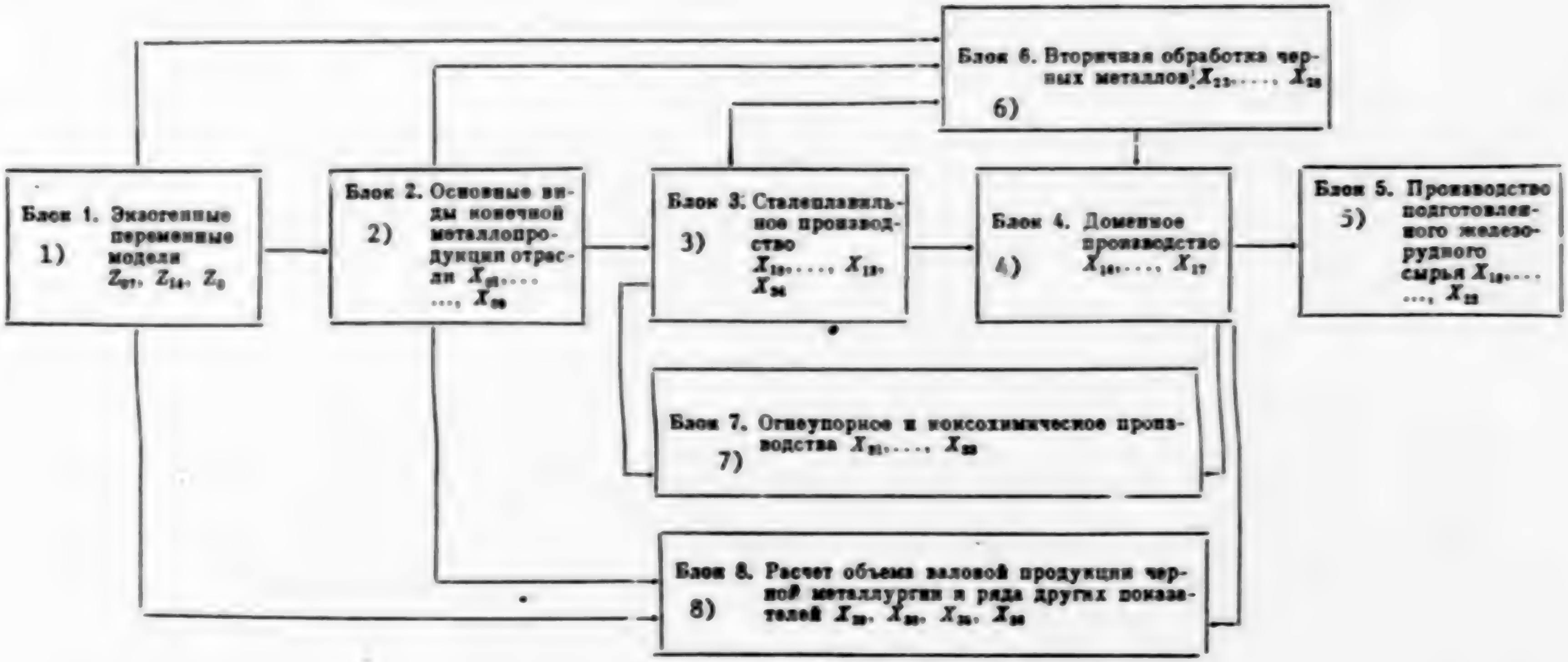
Блок 1. Экзогенные переменные модели Z_{07}, Z_{14}, Z_0
1)
Блок 2. Основные виды конечной металлопродукции отрасли $X_{01}, \ldots, X_{09}$
2)
Блок 3. Сталеплавильное производство $X_{10}, \ldots, X_{13}$, X_{34}
3)
Блок 4. Доменное производство $X_{14}, \ldots, X_{17}$
4)
Блок 5. Производство подготовленного железорудного сырья $X_{18}, \ldots, X_{22}$
5)
Блок 6. Вторичная обработка черных металлов $X_{23}, \ldots, X_{28}$
6)
Блок 7. Огнеупорное и коксохимическое производства $X_{31}, \ldots, X_{33}$
7)
Блок 8. Расчет объема валовой продукции черной металлургии и ряда других показателей X_{29}, X_{30}, X_{35}, X_{36}
8)

Figure 1. Integrated Diagram of Model Interrelationships

Key:

1. Block 1. Exogenous variables of model
2. Block 2. Basic kinds of final metal products of the industry
3. Block 3. Steelmaking production
4. Block 4. Blast furnace production
5. Block 5. Production of prepared raw iron ore
6. Block 6. Secondary processing of ferrous metals
7. Block 7. Refractory and coking byproduct production
8. Block 8. Calculation of volume of gross output of ferrous metallurgy and of a number of other indicators

The composition of metal scrap is calculated by means of variables from different blocks of the model, whereby the dynamics of their relationships limit structural rearrangement in the use of scrap.

In addition to the variables and interrelationships in the model indicated in the diagram, expenditures for the repair and maintenance of technological equipment and a number of other indicators were also estimated. These costs are now increasing at a rapid rate as the result of the rapid wear and obsolescence of equipment and their growth is of an essentially nonlinear nature in proportion to the accumulation of the active portion of fixed capital.

The statistical basis of the model is dynamic series of individual parameters from 1960 through 1976. Of course, by 1960 all of the above-mentioned subindustries, as well as the key technological methods of production, had been formed in the USSR's ferrous metallurgy industry, the renewal period had been completed, and the structure of the industry proved to be able to a greater degree to react to a change in national economic demand.

With information for this period calculations were made for 1977-1980 and their results were compared with actual data. At the same time the quality of estimates of the system of equations and the correctness of the description selected were verified. Estimates of parameters, both for the entire period and for the last 11 to 13 years, were obtained for practically all equations. Consequently, two models differing somewhat in the quantitative values of parameters were tested in verifying the quality of forecast calculations. The variation factor (V, as a percentage), Darbin-Watson (DW) statistics and standard errors in estimates of parameters (σ) were used for the purpose of this verification.

Because of the fact that the major portion of variables appear as endogenous in some equations and exogenous in others, it is necessary to make an estimate of parameters by special methods. The problem consists essentially in the following: It is impossible to use the ordinary estimation procedure, e.g., the method of least squares, for regression equations in which an indicator itself described by means of a regression equation is included in the structure of explanatory variables. Errors in determining an indicator of this sort will, generally speaking, be associated with errors in other variables (and equations) and the accumulation of errors in one or more equations is possible in forecast calculations.

Estimates of parameters obtained by means of a two-step procedure are presented below.* It should be mentioned that their refinement at the second step was

---

*Problems of identifying systems of regression equations are discussed in sufficient detail in a number of studies; therefore, it is necessary to justify only the reason for selecting a two-step estimation procedure. It is that in each equation all explanatory variables are expressed by means of exogenous ones and, thus, do not contain errors. The model discussed here reduces to a recursion system, because of which many difficulties in estimating parameters are eliminated. The advantage of the recursion system is the possibility of the successive calculation of endogenous variables in forecasting and analyzing the errors of each

[Continued on following page]

minimal, since not more than two indicators were included in the structure of explanatory variables and this procedure usually does not exert a considerable influence on simple interrelationships. Alternative estimates of parameters are performed only for some regression equations.

The volume of metal products (X_{05}) produced by the industry is defined as the sum of shipments of sheet (X_{01}) and bar (X_{02}) rolled stock and pipes (X_{04}):

$$X_{05}=X_{01}+X_{02}+X_{04}, \tag{1}$$

where the sum of the first two components gives the volume of finished rolled stock (X_{03}),

$$X_{03}=X_{01}+X_{02}, \tag{2}$$

whereby the behavior of each of them is described by the equations:*

$$\underset{(0,9)}{X_{01}=31,3} - \underset{(11,3)}{\frac{228,5}{t+10}} + \underset{(0,004)}{0,098}\, Z_{07}, \quad V=1,25,\ DW=1,6, \tag{3}$$

$$X_{02}=\underset{(1,1)}{1,8}\,Z_{14}^{\underset{(0,1)}{0,40}}\, Z_{07}^{(\underset{(0,3)}{0,41}-\underset{(0,5)}{8,1}/(t+10))}\, e^{-\underset{(0,03)}{0,003}t}, \quad V=1,66,\quad DW=1,7, \tag{4}$$

$$X_{04} = \underset{(1,1)}{8,0} - \underset{(8,5)}{\frac{68,9}{t+10}} + \underset{(0,02)}{0,1}\, Z_{14} + \underset{(0,005)}{0,013}\, Z_{07}, \quad V=1,4,\ DW=1,3. \tag{5}$$

Variable Z_{14} is omitted in (3) because shipments to this industry are relatively not too large and the change in this demand factor is described satisfactorily by means of a hyperbolic time trend. The equation for rolled bars is of an essentially nonlinear nature and the effect of machine building dynamics on shipments of rolled bar stock is intensified with time. In the transformed notation for

---

equation individually. In our opinion, special attention should be paid to those endogenous variables whose dynamics are determined from balance identities.

*The standard errors of estimates of parameters (σ) are given in parentheses; Z_{07} and Z_{14} represent the gross product of machine building (including metalworking) and construction, respectively, in billions of rubles; and t is the time index ($t = 1$ for 1960). The remaining indicators are expressed in millions of tons.

annual rates of growth equation (4) is reduced to

$$\frac{\Delta X_{0,2}}{X_{02}}=0{,}68\frac{\Delta Z_{16}}{Z_{16}}-0{,}063+\left(0{,}41-\frac{3{,}1}{t+10}\right)\frac{\Delta Z_{07}}{Z_{07}}+\frac{3{,}1}{(t+10)^2}\ln Z_{07}.$$

Since the rates of growth of the gross output of the machine building industry exceeded 110 percent in the reporting period, with time, factors which reduce the synchronous dependence of the output of rolled bar stock on the gross output of the machine building industry become less significant and the dynamics of X_{02} are determined more and more by factor Z_{07}, which is associated in part with a reduction in the rate of growth of the gross product of the construction industry.

A hyperbolic trend is used also in (5). Here estimates of parameters are relatively stable, which testifies to the adequacy of the description of the time series in question.

The output of metal products for industrial purposes is described by the equation

$$X_{06}=4{,}83-\frac{3{,}49}{t+10}+0{,}075Z_{16}+0{,}0059Z_{07},\quad V=1{,}26,\quad DW=1{,}6.$$
$$\qquad(0{,}6)\quad(5{,}1)\quad(0{,}01)\qquad(0{,}003)\tag{6}$$

For the purpose of estimating the dynamics of the production of ferrous metal castings (X_{09}) autonomous equations are used respectively for pig iron and steel casting (X_{07} and X_{08}), whereby

$$X_{09}=X_{07}+X_{08}.\tag{7}$$

$$X_{07}=10{,}79+0{,}0097Z_{07}+0{,}34t,\quad V=1{,}9,\quad DW=1{,}41,$$
$$(0{,}14)\quad(0{,}005)\quad(0{,}05)\tag{8}$$

$$X_{08}=1{,}92+0{,}077Z_{07}+0{,}018X_{10-1},\quad V=2{,}75,\quad DW=1{,}9$$
$$(0{,}27)\quad(0{,}002)\quad(0{,}004)\tag{9}$$

Whereas in (8) the only explanatory variable is the gross product of the machine building industry, for steel casting it is important to take into account also the dynamics of steelmaking production as a whole (X_{10}), which consumes a rather considerable amount of this kind of product, which also made it necessary to take into account a lag variable in (9), i.e., x_{10-1}. For the purpose of comparison let us consider the dependence comprising the production of steel in the current year:*

$$X_{08}=2,39+0,0095Z_{07}+0,011X_{10}, \quad V=2,41, \quad DW=1,11.$$
$$(0,3) \quad (0,002) \quad (0,006)$$

The steelmaking process is one of the most important production processes of the ferrous metallurgy industry and its structure is a major indicator of the level of development of the industry as a whole:

$$X_{10}=1,73(X_{05}+X_{08})^{(0,88-0,012/(t+10))}, \quad V=0,7, \quad DW=2,1,$$
$$(0,3) \qquad (0,06) \quad (0,01) \tag{10}$$

$$X_{11}=0,01W_1X_{10}, \tag{11}$$

$$W_1=\begin{cases} 84,69 & \text{with } t\leq 4, \\ 118,5-0,39X_{10} & \text{with } t\geq 5, \quad V=1,3, \quad DW=1,9, \\ (1,9) \quad (0,1) & \end{cases} \tag{12}$$

$$X_{12}=\begin{cases} -2,9+0,6\ X_{26} \text{ with } t\leq 4, \quad V=2,8, \quad DW=1,9, \\ (0,3) \quad (0,01) \\ 39,6W_1^{-0,83}X_{26}^{0,97} \text{ with } t\geq 5, \quad V=2,5, \quad DW=1,6, \\ (5,6) \quad (0,5) \quad (0,3) \end{cases} \tag{13}$$

$$X_{13}=X_{10}-X_{11}-X_{12}, \tag{14}$$

where X_{11}, X_{12} and X_{13} represent the total production of oxygen converter, electric furnace steel and open-hearth steel, respectively; X_{26} is the amount of the formation of obsolete scrap in industries of the national economy; and W_1 is the percentage of the production of open-hearth steel.

---

*The addition of the lag variable in (9) complicates the procedure for a two-step estimate of the model's parameters inconsiderably, since there are only two such variables in it.

The use of switching functions in (12) and (13) is explained by the fact that at the boundary of 1964-1966 the percentage of open-hearth steel, of the total amount of steel produced, was reduced, which is described by expression (10), and after 1964-1966 this percentage was reduced steadily. Identities (11) and (14) reflect the structural components of the total output of steel.

The dynamics of electric furnace ferroalloy production (X_{34}) are determined by the fact that the key consumer of this product is steelmaking:

$$\underset{}{X_{34}=-1{,}82}+\underset{(0{,}3)\ (2{,}9)}{\frac{5{,}33}{t+10}}+\underset{(0{,}001)}{0{,}035\ X_{10}},\quad V=2{,}1,\quad DW=1{,}2. \tag{15}$$

The structure of the blast furnace process of the ferrous metallurgy industry (block 4) is closely tied not only to steelmaking but also to the secondary processing of ferrous metals:

$$X_{15}=\underset{(13{,}1)}{-27{,}07}+\underset{(5{,}1)}{\frac{162{,}2}{t+10}}+\underset{(0{,}06)}{1{,}56}(X_{10}-X_{28}),\quad V=1{,}1,\quad DW=2{,}2, \tag{16}$$

$$X_{14}=\underset{(17{,}2)}{24{,}9}-\underset{(38{,}6)}{\frac{176{,}9}{t+10}}+\underset{(0{,}03)}{0{,}76}\ (X_{15}+X_{67}),\quad V=0{,}8,\quad DW=2{,}0, \tag{17}$$

$$X_{17}=X_{14}-X_{15}, \tag{18}$$

$$X_{16}=X_{15}+1{,}26X_{17}{}^{*}. \tag{19}$$

The dynamics of the production of conversion pig iron (X_{15}) depend on the total shortage of the metal burden used for the production of steel with the available resources of metal scrap which is consumed for producing the required quantity of it (X_{28}). When seen from (16), technical progress is expressed as a reduction in norms for the consumption of the burden in the production of steel. Actually, with time the influence of other factors on X_{15} --A(t) = - 27.07 + 162.2/(t+10)-- is somewhat reduced. The total amount of pig iron produced (X_{14}) is determined by the dynamics of the production of the conversion pig iron totally used in the production of steel and of cast iron produced basically out of metal scrap and foundry pig iron (X_{17}), as follows from (18) and (17). Equation (19) gives an estimate of the total output of pig iron in terms of conversion pig iron (X_{16}) for the purpose of providing comparability of the technological complexity of its production in relation to metallurgical coke, whose share of the production cost of pig iron reaches 40 percent [11, p 92].

---

*The figure 1.26 represents the factor for the conversion of foundry pig iron into conversion pig iron, in terms of the consumption of metallurgical coke [10, p 468].

The structure of the output of prepared raw iron ore (X_{18}) is determined by analogy with steelmaking production:

$$X_{18}=53{,}6-\frac{635{,}9}{t+10}+1{,}45X_{14},\quad V=1{,}2,\quad DW=1{,}9, \qquad (20)$$
$$(2{,}7)\quad(115{,}5)\quad(0{,}1)$$

$$W_2=\begin{cases}100{,}0 & \text{with } t\lessgtr 4,\\ 126{,}15-0{,}23X_{18} & \text{with } t>5,\quad V=0{,}7,\ DW=2{,}0,\\ (1{,}8)\quad(0{,}008) & \end{cases} \qquad (21)$$

$$X_{19}=0{,}01W_2X_{18}, \qquad (22)$$

$$X_{20}=X_{18}-X_{19}, \qquad (23)$$

$$X_{21}=-79{,}33+\frac{943{,}4}{t+10}+1{,}49\quad X_{18},\quad V=1{,}25,\quad DW=1{,}2, \qquad (24)$$
$$(53{,}6)\quad(219{,}0)\quad(0{,}09)$$

$$X_{22}=1{,}64X_{18}^{0{,}81},\quad V=6{,}9,\ DW=1{,}5, \qquad (25)$$
$$(0{,}7)\quad(0{,}05)$$

where W_2 is the percentage of sinter of the total volume of the production of prepared raw iron ore and X_{19}, ..., X_{22} represent the production of sinter, blast furnace pellets, and commodity iron and manganese ore, respectively.

The key consumer of iron and manganese ore is strictly the production of sinter and blast furnace pellets; therefore, X_{18} is the sole explanatory variable in (24) and (25). The use of other explanatory variables in (25) is possible, since relatively great quantities of manganese ore are consumed in the blast furnace process and go toward exportation [9, p 174; 12, p 25]. The influence of the latter factor, not taken into account, also explains the relatively high value of the variation factor. For the sake of comparison let us present the equation:

$$X_{23}=21,1+\left(0,005-\frac{3,2}{t+10}\right)X_{16}, \quad V=13,4, \quad DW=0,6.$$
$$(0,72)\ (0.003)\ (1,92)$$

One interesting and complex problem in modeling the structure of the production of the ferrous metallurgy industry is identification of the structure of the secondary processing of ferrous metals. The point is that metal scrap is a highly important raw material for modern metallurgy.

In the model the components of metal scrap resources are expressed directly in terms of sources of its receipt. For example, the amount of scrap obtained from metalworking industries (X_{23}) is determined by the proportions of sheet and bar rolled stock used by them. The return scrap of the ferrous metallurgy industry (X_{24}) depends on the scale of the steelmaking process, and the obsolete scrap (X_{26}) is described by a system of equations and equalities employing an auxiliary variable, X_{25} --the nominal time gap between the period of the direction of ferrous metals into the national economy (including products made of them) and of the formation of the same amount of obsolete scrap resources [13]. The total amount of scrap resources (X_{27}) is described by the balance equation:

$$X_{27}=X_{23}+X_{24}+X_{26}, \tag{26}$$

whereby

$$X_{23}=1,27X_{01}^{0,28} \quad X_{03}^{0,83} \quad e^{0,0171t}, \quad V=1,6, \quad DW=1,9,$$
$$(0,4)\ (0,14)\ (0,19)\ (0,007) \tag{27}$$

$$X_{24}=14,15-\frac{58,64}{t+10}+0,20X_{18}, \quad V=1,2, \quad DW=1,9,$$
$$(11,7)\ (25,49)\ (0,01) \tag{28}$$

$$X_{25}=11,36+0,65t, \quad V=0,9, \quad DW=1,6,$$
$$(1,4)\ (0,008) \tag{29}$$

$$X_{20}=X_{16}+Z_{6}, \tag{30}$$

$$X_{26}=X_{20_{-x}}+\beta\Delta X_{20_{-\Delta x}} \tag{31}$$

where α is the whole part of X_{25} ; β is the fractional part of X_{25} ; and X_{29} and Z_0 are respectively the size of the "metal investment" and the total foreign trade balance of ferrous metals and products made from them.

Estimates of the parameters of equations (27) to (29) are stable relative to variation in the sampling interval, especially in (29). Let us note also that the trend description of X_{26} gives a sixfold higher absolute error than does expression of the dynamics of obsolete scrap by means of expressions (29) to (31). Furthermore, the trend dependence looks like this:

$$\underset{}{X_{26}}=\underset{(8,4)}{14,0}+\underset{(0,03)}{0,53t}+\underset{(0,004)}{0,018t^2}, \quad V=1,1, \quad DW=1,6.$$

The amount of metal scrap consumed for the production of steel (X_{28}) is determined from the equation

$$X_{28}=\underset{(3,1)}{-5,08}+\underset{(0,01)}{0,85\,X_{27}}, \quad V=1,2, \quad DW=1,7, \tag{32}$$

and the leftover portion of the scrap ($X_{27} - X_{28}$) will go to the production of castings and for export needs.

The dynamics of the national economy's metal resources are as follows:

$$X_{30}=\underset{(11,8)}{-20,1}+\underset{(56,3)}{\frac{57,7}{t+10}}+\underset{(0,007)}{0,99(X_{30-1}+X_{29})}, \quad X=0,4, \quad DW=2,1, \tag{33}$$

where X_{30} represents the metal resources of industries of the national economy. Let us note that the amount of metal resources is one of the most important indicators of the level of development of the economy as a whole.

The dynamics of coking byproduct production follow from the variable of equation (19):

$$X_{31}=\underset{(12,9)}{45,0}-\underset{(53,1)}{\frac{113,9}{t+10}}+\underset{(0,04)}{0,31\,X_{19}}, \quad V=1,4, \quad DW=1,8, \tag{34}$$

$$X_{33} = -12,8 + \frac{54,9}{t+10} + 1,29\ X_{31}, \quad V = 1,2, \quad DW = 1,8.$$
$$(17,4) \quad (8,4) \quad (0,18) \qquad (35)$$

The output of metallurgical coke in (34) is explained by a growth in blast furnace production, whose product (pig iron) is referred to the comparable technological difficulty of production in terms of X_{15}, after which an estimate is made of the total amount of coke burnt (X_{32}).

The output of refractories is expressed in terms of the dynamics of the production of steel, to which about 60 percent of the total consumption of refractories is due [14, p 255]:

$$X_{34} = 1,05 + 0,098 X_{16} - 0,36t, \quad V = 2,8, \quad DW = 1,4.$$
$$(0,14) \quad (0,07) \quad (0,25) \qquad (36)$$

The third term in (36) expresses a comparative reduction in the share of the steelmaking process in the consumption of refractories. Other descriptions of this equation are also possible. For example, let us give:

$$X_{34} = 1,43\ X_{16}^{0,66} e^{-0,034t}, \quad V = 1,9, \quad DW = 1,9.$$
$$(1,1) \quad (0,4) \quad (0,02)$$

However, description (36) is more convenient in practical calculations, since the amount of consumption of refractory products in the steelmaking process indirectly determines the level of their consumption by other subindustries of the ferrous metallurgy industry and the dynamics of refractory production are expressed in (36) so that with saturation of the demand for absolute amounts of steel production this equation more accurately "states" the analogous saturation in refractory production.

The total gross output of the ferrous metallurgy industry (X_{35}) is described by a trend equation reflecting the growth in the ratio of X_{35} to $(X_{01} + X_{06})$:

$$\frac{X_{35}}{X_{01}+X_{06}} = 0,18 + 0,00088\ t, \quad V = 10,8, \quad DW = 1,4.$$
$$(0,001) \quad (0,0001) \qquad (37)$$

Another method of calculation is also possible, based on employing marketability factors with assigned prices. Generally speaking, with the statistical method of calculating index X_{35}, the value of the denominator in (37) should be reduced by the amount of metal products for industrial purposes produced in the machine building and metalworking industries, which equals about 35 percent of X_{06} [15, p 43]. However, if it is taken into account that X_{01} is greater than X_{06} by an order of magnitude, then the excess existing in the value of the denominator has an unsubstantial influence on the index to be calculated.

Similarly, we determine the amount of expenditures for the repair and maintenance of metallurgical equipment (X_{36} in millions of rubles):

$$\frac{X_{36}}{X_{01}+X_{06}} = \underset{(0,2)}{9,5} + \underset{(0,02)}{0,68}\, t, \quad V=2,3, \quad DW=1,1. \tag{38}$$

Thus, system of equations (1) to (38) describes the change in the production structure of the ferrous metallurgy industry. A distinctive feature of the model is the ability to estimate total expenditures for the output of basic kinds of products of the industry in terms of regression coefficients of individual equations.* Estimates of total physical input for such kinds of products as steel and cast iron differ by only 0.1 to 1.8 percent from values obtained from analyzing the industrial balance of the ferrous metallurgy industry. Consequently, the model constructed can expand considerably the range of economic problems which can be solved when it is reconciled intelligently with the industrial balance.

For the purpose of evaluating the quality of the model retrospective calculations were made and a forecast was also made of indicators of the development of the USSR's ferrous metallurgy industry up to 1985. A comparison of the results obtained with reporting data for 1960-1976 and 1977-1978 confirmed the high quality of the model constructed, in describing both production dynamics and the structure of technological subindustries. This follows from the statistical characteristics of the equations and table 1.

Flexibility factors of endogenous variables calculated relative to exogenous, Z_{07} and Z_{14}, are presented in table 2.

The mean ratio of flexibility factors, α_{14}/α_{07}, lies in the range of 1.8 to 2.1, which testifies to the dominating influence of machine building and metalworking on the development of the majority of metallurgy production processes.** An exception is those metallurgical processes whose products are directed primarily toward construction (metal products for industrial purposes, pipes) or whose greater share goes toward exportation (commodity manganese ore) [12, p 25].

---

*Such calculations are possible in view of the relative simplicity of relationships of the basic production line of the metallurgy industry.

**Let us note that the rate of growth of the volume of construction and erection work is 2.5- to threefold lower than the rate of growth of the gross product of the machine building and metalworking industries [9, pp 140, 364].

Table 1. Comparison of Calculated and Actual Indicators of the Production Structure of the Most Important Subindustries of the USSR's Ferrous Metallurgy Industry in Percentages

Indicators	1977		1978	
	Actual [9, pp 173, 119]	Calculated	Actual [9, pp 173, 119]	Calculated
Percentage of total output of finished rolled products				
Sheet	41.28	41.33	41.78	41.83
Bar	58.72	58.67	58.22	58.17
Proportion of total output of steel				
Open-hearth	62.86	62.00	61.71	60.19
Converter	27.05	27.74	28.20	29.42
Electric furnace steel	10.09	10.26	10.09	10.39
Percentage of conversion pig iron of the total amount of it produced	91.9	91.2	91.5	92.4

Table 2. Flexibility Factors for Basic Kinds of USSR Ferrous Metallurgy Industry Products

Products and conventional symbol for variable in model	Flexibility factors	
	α_{14}	α_{07}
Commodity iron ore (X_{21})	0.42	0.22
Commodity manganese ore (X_{22})	0.11	0.05
Prepared raw iron ore, total (X_{18})	0.37	0.19
Including		
Sinter (X_{19})	0.25	0.13
Blast furnace pellets (X_{20})	3.82	2.03
Pig iron, total (X_{14})	0.43	0.23
Steel, total (X_{10})	0.35	0.18
Including		
Open-hearth (X_{11})	0.16	0.08
Converter (X_{12})	1.71	0.89
Electric furnace steel (X_{13})	0.15	0.07
Pipes (X_{04})	0.46	0.08
Finished rolled products (X_{03})	0.42	0.25

[Continued on following page]

Secondary processing of ferrous metals, total (X_{27})	0.15	0.08
Including metal scrap consumed for steelmaking (X_{28})	0.16	0.09
Coke, total (X_{32})	0.16	0.08
Including metallurgical coke (X_{31})	0.14	0.08
Refractories (X_{33})	0.40	0.23
Metal products for industrial purposes (X_{06})	0.47	0.05
Gross product of metallurgy industry in terms of cost (X_{35})	0.41	0.19

An analysis of flexibility factors confirms the conclusion regarding taking into account in the model key trends in technical progress in the industry. Thus, the flexibility factor for blast furnace pellets is considerably higher than the similar indicator for sinter. It is precisely the output of blast furnace pellets which determines today's level of the output of prepared raw iron ore. The same pattern can be observed in steelmaking production and chemical byproduct production. Whereas in the first case the technical level of development of the process is associated with a growth chiefly in oxygen converter steel, in the second some savings of metallurgical coke--the most expensive product of coke production--is gained.

Bibliography

1. Shatalin, Yu.A., Chukhlova, L.N. and Vasil'yev, V.V. "Modeling the Development and Disposition of the Ferrous Metallurgy Industry" in "Modelirovaniye razmeshcheniya otrasley i khozyaystvennogo razvitiya ekonomicheskikh rayonov" [Modeling the Disposition of Industries and the Economic Development of Economic Areas], Moscow, USSR Gosplan Council for the Study of Productive Resources, 1978.

2. Shiryayev, P.A., Lebedev, Yu.G. and Karavayev, Ye.P. "Question of the Application of Mathematical Economics Methods in Longterm Planning of an Industry" in "Ekonomika i upravleniye v metallurgii" [Economics and Control in Metallurgy], Moscow, Metallurgiya, 1978.

3. "Model' mezhotraslevykh vzaimodeystviy" [Model of Interindustrial Interaction], Moscow, USSR Academy of Sciences Central Mathematical Economics Institute, 1976.

4. Gladyshevskiy, A.I. "Modeli i metody otraslevogo ekonomicheskogo prognozirovaniya" [Models and Methods of Industrial Economic Forecasting], Moscow, Ekonomika, 1977.

5. Yakimenko, G.S. and Khomenko, N.M. "Prognozirovaniye tekhniko-ekonomicheskikh pokazateley raboty metallurgicheskikh agregatov" [Forecasting of Technical and Economic Indicators of the Operation of Metallurgical Units], Moscow, Metallurgiya, 1979.

6. Zavitskiy, V.I. "Forecasting the Consumption of Steel Pipes from Factor Models," BNTI CHERNAYA METALLURGIYA, No 1, 1979.

7. Gavrilina, L.M. "Forecasting the Development of Ferrous Metallurgy Abroad," BNTI CHERNAYA METALLURGIYA, No 14, 1977.

8. Pavlenko, V.D. "Modeling the Structure and Dynamics of Steelmaking Production Volume" in "Ekonomika chernoy metallurgii" [Economics of Ferrous Metallurgy], Moscow, Metallurgiya, 1979.

9. "Narodnoye khozyaystvo SSSR v 1979 godu. Stat. yezhegodnik" [National Economy of the USSR in 1979; Statistical Yearbook], Moscow, Statistika, 1980.

10. Yefimenko, G.G., Ginel'farb, A.A. and Levchenko, A.Ye. "Metallurgiya chuguna" [Metallurgy of Pig Iron], Kiev, Vyshcha shkola, 1970.

11. Perlov, N.I., Yegolichev, A.P., Petrakovskiy, A.P., Fedotov, A.A. and Bannyy, N.P. "Tekhnicheskiy progress i toplivoenergopotrebleniye v chernoy metallurgii" [Technical Progress and Fuel and Energy Consumption in the Ferrous Metallurgy Industry], Moscow, Metallurgiya, 1975.

12. "Vneshnyaya torgovlya SSSR za 1979 god. Stat. sbornik" [USSR Foreign Trade for 1979; Statistical Compilation], Moscow, Statistika, 1980.

13. Pavlenko, V.D., Lebedev, Yu.G. and Zhitnikov, O.D. "Procedure for Estimating Obsolete Scrap Resources in the National Economy," BNTI CHERNAYA METALLURGIYA, No 6, 1980.

14. Vagin, A.A., Krivandin, V.A., Pribytkov, I.A. and Perlov, N.I. "Toplivo, ogneupory i metallurgicheskiye pechi" [Fuel, Refractories and Metallurgical Furnaces], Moscow, Metallurgiya, 1978.

15. Lempitskiy, V.V. "Key Trends in Technical Progress in Ferrous Metallurgy" in "Tekhnicheskiy progress v chernoy metallurgii SSSR" [Technical Progress in the USSR's Ferrous Metallurgy Industry], Moscow, Metallurgiya, 1977.

COPYRIGHT: Izdatel'stvo "Nauka", "Ekonomika i matematicheskiye metody", 1981

8831
CSO: 1842/136

OSKOL ELECTROMETALLURGICAL COMBINE

Moscow GUDOK in Russian 27 June 81 p 3

[Article by Engineer E. Zvonitskiy, Staryy Oskol: "Metal Without Blast Furnace"]

> [Text] "Continue establishment of a territorial-production complex based on the Kursk Magnetic Anomaly, and bring on-stream the first unit of the Oskol Electrometallurgical Combine" (From "Principal Directions of Economic and Social Development of the USSR for 1981-1985 and the Period Up to 1990")

Darting out of the city, an express streetcar, accelerating rapidly, speeds past birch groves and kolkhoz fields. Alongside the trolley line runs a broad highway, carrying a continuous stream of trucks laden with building materials, metal structures, and equipment. At the end of the "Kotel" line construction organization buses are waiting for the passengers. Several more kilometers of hard-surface roads, and the panorama of an All-Union Komsomol Shock-Work Construction Project opens up before one's eyes -- the Oskol Electrometallurgical Combine. Here, in the middle of the Central Russian Uplands, where the mighty ridge of the Kursk Magnetic Anomaly stretches hundreds of kilometers, the pioneer of the Soviet blast-furnaceless metallurgical industry is rising.

...We are in the office of Valentin Semenovich Kudryavtsev, the combine's chief engineer. For the time being one must picture the production technology from diagrams and drawings.

"One of the features of production without blast furnace is that natural gas will be utilized in place of coke," explains Kudryavtsev. "Therefore our combine will not pollute the water and atmosphere with toxic compounds like phenols and cyanides -- which are inevitably present in the coking and blast-furnace process. Direct reduction of iron also presupposes closed-cycle water use."

The bulk of the raw material will be supplied by the Lebedin Mining and Concentration Combine. The rich concentrate, with up to 70 percent iron content, will be fine-crushed and mixed with water, and the resulting slurry will be conveyed by a 26.5 kilometer pipeline at the speed of a mountain stream.

Settling tanks, the first stage in the processing chain, are enormous ponds 52 meters in diameter. Ore particles will settle out onto the bottom, while the water, passing through a system of filters, will return to the Lebedin Mining and Concentration Combine, where it will once again be used to convey ore in the slurry pipeline system. The settled residue will proceed by a system of conveyer belts to the pelletizing shop where, processed in vacuum-filters and mixing drums, it will be transformed into pellets.

The next link in the process chain is the metallization shop, which contains iron reduction units -- shaft furnaces 50 meters tall and 8 meters in diameter. These are highly complex pieces of equipment involving hundreds of mechanisms and instruments which guide and monitor the process. The resulting product is sent to electric arc furnaces in the steelmaking shop.

The second unit of the combine will also include a complete process cycle. The four 200-ton arc furnaces of this unit will produce from one and a half to two million tons of alloy steel each year.

"The Oskol Electrometallurgical Combine design represents the state of the art of world metallurgical science and practices," states the director of this enterprise under construction, Vladimir Alekseyevich Bashkov. "The new technology will make people's jobs safer and will substantially reduce production costs. All processes will be performed by high-output equipment, automated lines and rolling mills."

Computers will be extensively employed at the combine. Production control will be handled from a unified EDP center. The industrial processes and operations of all the subdivisions of the enormous installation will be monitored from here. Hundreds of screen displays will provide the operators with the necessary data.

Things are presently in full swing at the construction site. They are working on the production facilities, on construction of water lines, boiler house, railway trackwork between shops, a streetcar depot, hothouses, apartment buildings and dormitories. The city of Staryy Oskol is taking on new features.

People from all union republics are building the Oskol Combine. Recent arrivals include the Shock-Work Detachment imeni 26th CPSU Congress. Boys and girls from Kirghizia, Tajikistan and Turkmenia have joined the ranks of construction workers and are laboring productively on the numerous facilities. Student detachments work here every summer. Komsomol headquarters determines in advance where they will be working and sets up meetings between student construction detachment commanders and secretaries of the Komsomol organizations of the construction administrations in which the students will be working. Over the summer the detachments accomplish tens of thousands of rubles worth of cosntruction. Last year students from Armenia, Dagestan, and the Ukraine were working at Staryy Oskol, while this year students have come from Moscow and Khar'kov.

In the evening we got together with Anatoliy Kanaychev, headquarters chief of the All-Union Komsomol Shock-Work Construction Project, to learn how the members of the Komsomol shock-work detachments are doing.

The nine-story building housing Elektrometallurgstroy Dormitory No 1 is ablaze with light. Music wafts from the windows. A group of lads are watching television in the education and propaganda room. In an adjoining room they are playing chess and checkers. Evenings of popular music, sports competitions, and excursions are arranged for the young construction workers. Dormitory area facilities include a propaganda site, a library, an education and propaganda room, a post office, a personal services facility, a store, a bookseller's kiosk, and a medical aid station....

The young people like it in Staryy Oskol. Many of today's construction workers are already thinking about settling down permanently in this city and making a career at the metallurgical combine. All conditions have been created for this. Boys and girls can master a metallurgical trade, while still working full time, at the base vocational school and at a branch of the Moscow Steel and Alloys Institute.

The coat of arms of Staryy Oskol consisted of three partridges, a gun, and a plow.

"Very straightforward symbols," stated Nina Yegorovna Chmil', director of the local regional studies museum. "The three partridges symbolize that our city was part of Kursk Gubernia, the gun symbolizes that military people lived here, and the plow -- that farming was the principal occupation of the local populace.

"Materials have been found in the Central State Ancient Documents Archives," related Nina Yegorovna, "indicating that one of Russia's biggest ironworks was operating in Oskol in the middle of the 17th century. There was a shop here which manufactured gun barrels: small-caliber harquebus, large-caliber harquebus, and pieces for firing canister shot. The descendents of these nameless artisans are today building a new, giant plant -- a trailblazer of the metallurgical industry."

3024
CSO: 1842/148

UKRAINIAN FERROUS METALLURGY GOALS IN 11TH FIVE-YEAR PLAN

Kiev EKONOMIKA SOVETSKOY UKRAINY in Russian No 3, Mar 81 pp 3-10

[Article by N. Tereshchenko, Ukrainian SSR Gosplan deputy division chief, candidate of economic sciences: "Ferrous Metallurgy of the Ukrainian SSR in the 11th Five-Year Plan"]

[Text] Big goals relating to a further growth in capacities and the total output of products, speeding technical progress and improving production efficiency, improving quality and expanding the assortment of metal products confront the ferrous metallurgy industry as one of the basic industries of the national economy in the "Main Guidelines for the Economic and Social Development of the USSR for 1981-1985 and for the Period to 1990." The Ukraine--one of the leading metallurgical bases of the country--must make an important contribution toward the realization of these goals.

In the Ukrainian SSR during the 11th Five-Year Plan period the goal is to increase the output of finished rolled products by 14 to 16 percent and the production of cast iron, steel, iron ore and coke is to make corresponding advances; the output of steel pipes, metalware and other ferrous metallurgy products will also increase.

The trend of further strengthening force factors in a growth in output has been adopted in the new five-year plan period. A more than 65-percent growth in ferrous metallurgy commodity products should be gained on account of reconstruction and modernization and improvement of the performance of existing capacities on the basis of speeding technical progress and of the fuller utilization of internal potential. The industry is faced with the problem of achieving the total mastery of planned capacities and of the technical and economic indicators for the performance of all units and projects previously put into service.

A considerable amount of capital construction work is to be carried out at enterprises of the republic's ferrous metallurgy industry. Considerable changes will take place in the structure of capital investment called upon to improve their efficiency. Capital investment in retooling and for the reconstruction and maintenance of existing capacities, which equal 50 to 52 percent of the total amount of capacities in the industry, will increase by almost 30 percent as compared with the 10th Five-Year Plan period. About 37 percent of capital investment is earmarked for development of ferrous metallurgy's raw material base. Considerable capital is being allotted for the construction of housing, projects for public and social and cultural purposes and for the protection of air and water basins.

One of the key objectives for development of the republic's ferrous metallurgy industry for the the 11th Five-Year Plan period is further expansion of the raw material base, improvement of the quality of the preparation of raw iron ore, the upkeep of existing mining enterprises, and bringing up to the planned level working conditions and the output and quality of raw iron ore. New capacities are to go into service at the North, South, Central, Novokrivorozhskiy, Pervomayskiy and Kamysh-Burunskiy mining and concentrating combines. In addition, in the Krivbassruda Association considerable capacities will be put into service for mining raw iron ore to replace disappearing levels and mines. A considerable amount of work is planned to be carried out for surmounting the lag in stripping operations at the strip mines of mining and concentrating combines, in particular of the North, Dneprovskiy and Inguletskiy, for the purpose of achieving the required quality of raw iron ore arriving for concentration. Capacities for the mining and concentration of manganese ore in the Nikopol'skiy Manganese Basin will increase and construction will be begun on the Tavricheskiy Mining and Concentration Combine at the Bol'she-Tokmakskoye Deposit. A combination of work is to be carried out relating to the retooling of steel making, rolled metal, pipe and metalware production for the purpose of making it possible to improve the quality and expand the assortment of metal products, as well as to reduce the consumption of metal in metallurgical processes.

An oxygen converter plant is to be put into service at the Dneprovskiy Metallurgical Plant imeni Dzerzhinskiy and electric furnaces at the Donetsk and Azovstal' plants. A number of plants for the out-of-furnace treatment of steel with synthetic slag and a vacuum will begin to operate. The "3000" plate mill with a regulated rolling cycle at the Zhdanov Plant imeni Il'ich will begin to produce products, as well as the "550" heavy merchant mill for the production of shapes with complicated cross sections at the Dnepropetrovsk Plant imeni Petrovskiy and the "300" small-section mill for rolling alloy steel at the Donetsk Metallurgical Plant.

New plants will be built for the production of corrosion-resistant pipes for the sugar industry and two-ply welded pipes for gas lines at the Novomoskovsk Pipe Plant, for the production of clad metal pipes at the Dnepropetrovsk Pipe Rolling Plant imeni Lenin, and for the production of drawn pipes at the Nikopol' Yuzhnotrubnyy [Southern Pipe] Plant, as well as a number of other pipe industry projects.

Additional capacities are to be put into service at the Nikopol' and Zaporozh'ye ferroalloy plants and at enterprises producing advanced refractory materials. The Brovary Powder Metallurgy Plant will be given further development. At metallurgical plants and enterprises of the Ukrvtorchermet Industrial Association the plan is to put into service for the processing of metal scrap 2.2-fold more capacities than in the 10th Five-Year Plan period.

Rolling mills are to be reconstructed at the following metallurgical plants: the Dneprovskiy imeni Dzerzhinskiy, the Makeyevka, Krivorozhstal', Yenakiyevo and Kommunarsk. A number of pipe plant units and plants will be reconstructed at the Nikopol' Yuzhnotrubnyy, Dnepropetrovsk imeni Lenin, Nizhnedneprovskiy imeni

K. Libknekht and Novomoskovsk plants, as well as a number of enterprises producing refractories, ferroalloys and metalware.

One of the main objectives of the 11th Five-Year Plan is to speed scientific and technical progress as the decisive condition for the intensive development and improvement of the efficiency of public production. This will be expressed in further improvement of the level of intensification of technological processes and improvement of the utilization of production capital on this basis. In the new five-year plan period the intent is to improve the utilization factor for mining and transportation equipment at mines, strip mines and concentrating and pelletizing plants on account of the concentration and specialization of mining operations, the use of machinery complexes, the introduction of advanced technology, and improvement in the organization of production and labor.

A major means of stepping up the production process in blast furnace and steel smelting production is the utilization of oxygen. The utilization of oxygen will increase 1.6-fold during the five-year plan period at the republic's metallurgical plants on account of the construction of a number of large oxygen units. In blast furnace production stepping up of the technological process and improvement of the productivity of blast furnaces will also be achieved on account of a 0.8- to 1-percent increase in the iron content in blast furnace ore, as well as an increase to 99 to 100 percent of the percentage of sinter and pellets in the burden, a 4- to 5-percent reduction in the content of fines in the sinter, increasing the temperature of the blast and the pressure of the gas under the top of the furnace, etc. In steelmaking production the intensity of oxygen lancing of the metal in converters will be increased 15 to 20 percent, the charging period will be shortened on account of improvement in preparation of the scrap and the durability of the lining will be increased 1.3-fold on account of the extensive introduction of concrete spraying.

In the 11th Five-Year Plan period it is necessary to carry out a number of engineering and management measures aimed at improving the control and organization of production, the observance of production process schedules for the work of combined sections and plants of enterprises and subindustries, the reduction of downtime and improvement of the operating reliability of units. As the result of this, the mean 24-hour production of pig iron from one cubic meter of the useful space of blast furnaces should increase by 0.1 tons, of steel by 1.8 tons from one ton of the nominal capacity of converters, and by 1.2 tons from one square meter of the hearth of open-hearth furnaces. The hourly productivity of individual rolling mills should increase by 8 to 10 percent, and of pipe units by 10 to 12 percent. The intensity of the operation of sintering machinery, coke-oven batteries and other metallurgical equipment will increase.

Significant work will be carried out in each subindustry of the ferrous metallurgy industry relating to the extensive introduction of new advanced equipment and technological processes and to the solution of a number of urgent technical and economic problems for the purpose of improving the efficiency and quality of work. Purposeful complex scientific and technical programs have been developed and are being developed for the majority of these problems and trends.

In connection with the limited resources of caking coal in the republic, an important objective of blast furnace production is reduction of the consumption of coke, which is a key factor in reducing the cost of cast iron and improving the efficiency of metallurgical processing. In the new five-year plan period the objective will be set of reducing the specific consumption of coke by 40 kg. This will make it possible to save about two million tons of coke in 1985, which will reduce physical input by 85 million rubles, the demand for coal by 3.5 million tons and capital investment by 120 million rubles. An extensive work program has been designed for the purpose of solving this problem. An important potential for reducing the consumption of coke is reducing the production of ferromanganese in blast furnaces, in the production of which the consumption of coke is 2.5-fold higher than in the production of pig iron. Considerable work must be done on reducing the consumption of coke in other branches of industry, too, primarily on account of changing to anthracite and natural gas in the burning of lime, in which the consumption of coke equals about one million tons at the present time.

The production of metallurgical formcoke from loosely caking coal, which will become possible with the entry into service of a unit at the Bagleyskiy Coking By-product Plant, is slated to be introduced on an experimental industrial scale. In the future this can totally solve the problem of coal resources for coking.

In steelmaking production the main line of technical progress is the development of the oxygen converter and electric furnace steelmaking processes and improvement of their equipment and technology. During the years of the 11th Five-Year Plan, because of the construction of new units and reconstruction and improvement of the performance of existing ones, the output of converter steel will increase 1.3-fold and of electric furnace steel 1.5-fold. With the entry into service of a new foundry at the Dneprovskiy Plant imeni Dzerzhinskiy, for the first time in the country the technology of bottom blowing of metal in converters will be introduced on an industrial scale, which will make it possible to reduce melting loss and to increase the output of suitable metal. The use of out-of-the-furnace treatment of metal will be expanded in electric furnace steelmaking plants. Conditions for the utilization of oxygen which are optimal for conditions existing at each plant and which will make possible maximum productivity must be worked out in open-hearth plants.

An important potential for improving productivity and efficiency in steelmaking plants is improving the level of preparation of scrap. Calculations have demonstrated that increasing the bulk density of scrap in charging boxes from the 1.1 to 1.15 tons per cubic meter reached in the republic's metallurgical plants in 1980 to the 2 to 2.3 tons per cubic meter required by modern technology will make it possible to produce in existing steelmaking plants more than two million additional tons of steel per year, to reduce by 1.5 to 1.8 percent the consumption of the metal burden, to save about one million tons of pig iron and to reduce physical input by almost 55 million rubles. An extensive program for the development of scrap processing capacities and for improving the utilization of existing equipment is slated for the 11th Five-Year Plan period.

One of the main lines of technical progress, of reducing materials intensiveness and of improving production efficiency in ferrous metallurgy is economizing on iron in metallurgical processes. According to the data of VNIIOchermet [All-Union

Scientific Research Institute of the Organization of Production and Labor in Ferrous Metallurgy], the percentage of iron converted from raw iron ore into commodity metal products in metallurgical processing stages is 64 percent at the present time; the remainder is expended in waste and losses.

In recent years the index for the consumption of iron in blast furnace production has worsened. For the republic on average it equals 1025 kg per ton of conversion pig iron, while it equals 989.2 kg at the Azovstal' Plant. Achievement of this index at the Azovstal' level by all plants would make it possible to save about 3.5 million tons of raw iron ore and to reduce conversion costs by 35 million rubles. For this purpose measures must be carried out to reduce the escape of blast furnace dust, to improve the design of the main troughs of blast furnaces for the purpose of reducing losses of metal with the slag, to improve weighing equipment, etc.

There is considerable potential in the republic's metallurgical plants for reducing the consumption of the metal burden in steelmaking production. The quality of pig iron and of the preparation of scrap will be increased, the technology for the utilization of oxygen will be improved, converter plants will be better supplied with lime, and losses from rejects and the amount of scrap and short-run castings, etc., will be reduced. This will make it possible to reduce the consumption of metal burden in steelmaking production by 350,000 to 400,000 tons per year, and physical input by 26 million to 30 million rubles.

The 11th Five-Year Plan period is faced with high goals for the reduction of the consumption of metal in the production of rolled products. On account of the entry of capacities into service at the Donetsk Metallurgical Plant and of the fuller mastery of machinery at the Azovstal' Plant, the extent of steel casting with machines for the continuous casting of billets will be increased, which will produce an 8- to 12-percent savings of metal as compared with pouring into ingots. A number of measures have been provided for improving the technology of jacketing for warmth-keeping the leading portion of killed steel ingots on account of the use of more effective heat-insulating plates in combination with exothermic mixtures providing an up to 5-percent savings of metal, primarily at the Krivorozhstal', Dneprovskiy imeni Dzerzhinskiy, Yenakiyevo, Kommunarsk and Makeyevka metallurgical plants. The pouring of steel from ladles equipped with slide gates will make it possible to reduce the consumption of metal into scrap by 1 to 1.5 percent. About 35 percent of steel produced at metallurgical plants is now poured by this method, but it is already technically feasible to introduce it in totality. The volume of rolled products with negative tolerances is to be increased 1.4- to 1.5-fold and fuller use is to be made of negative tolerance fields in rolling and supplying rolled metal, in terms of theoretical weight, which produces a savings of about 1 to 2 percent of metal in rolling mill shops. For this purpose new prestressed stands have been installed in a number of mills, the modernization of rolling equipment is being carried out, and improved systems are being introduced for automatically regulating the thickness and weight of the metal in terms of the length of the rolled product.

At all metallurgical plants measures must be carried out to improve the shapes of ingot molds and ingots, to improve the technology for the deoxidation and pouring of steel, to improve the location and spacing of billets and accounting for metal in the processing process, and to introduce effective systems of providing material incentives for workers to save metal in metallurgical processes on the basis of introducing combined systems for controlling product quality and for the efficient utilization of resources. The accomplishment of these measures will make it possible to gain a savings of metal in the rolling process stage in metallurgical plants to an extent of 600,000 to 700,000 tons, having lowered process stage costs by 65 million to 75 million rubles per year.

One of the main lines of technical progress in the industry is further speeding the introduction of computer technology for the purpose of automating the control of production and technological processes. Standard ASU's [automated control systems] will be widely introduced in identical technological processes, and plans have been made for the creation of a number of ASUTP's [automated systems for controlling technological processes] and ASUP's [automated systems for controlling enterprises] based on third-generation computers, and for the expansion of existing and the creation of new computing and data processing centers at enterprises, and in organizations, as well as of multiple-user centers serving specific regions. The industrial sector ASU will be given further development and the number of problems which it can solve will be increased. There will be 1.6-fold more computers operating in the industry in 1985 as compared with 1980, and the degree of their utilization will be increased.

The level of the mechanization of heavy and labor-intensive work will increase during the years of the 11th Five-Year Plan period, which will make it possible to solve many technical, economic and social problems, in particular, the improvement of labor conditions, the release of workers involved in manual labor, and the enlistment and assignment of personnel. The pace of this work must be increased 1.4- to 1.5-fold as compared with the 10th Five-Year Plan period.

In machine building it is necessary to put into order the production of about 80 models of machines and machinery already tested under production conditions, for the purpose of supplying all metallurgical enterprises with them. The extent of the production of series-produced machines and gear for mechanizing labor-intensive operations, in repair and other auxiliary services in particular, will be increased considerably. It is necessary to expand and speed considerably the performance of scientific research and planning and design studies relating to the development and introduction of equipment for mechanizing complex operations, such as the checking, sorting and packaging of rolled products, pipes, metalware, refractories and other products, to the use of tubular container, conveyer and other labor-saving advanced forms of transporting loads, and to the use of automata and robots. It is also necessary to create and introduce new high-efficiency complexes of machines, combined in operation, for the mining industry, making possible the intelligent utilization of each machine, and for the total mechanization of services for large metallurgical units, relating to the mechanization of labor-intensive processes in the refractory, coking byproduct and metalware industry and to the repair of equipment. VNIIMekhchermet [All-Union Scientific Research Institute of Mechanization of Ferrous Metallurgy], which is the leader in the industry with regard to problems in mechanizing labor-intensive work, is faced with big problems in this area. In it it is planned to create an experimental production base for the production of experimental models and prototypes of special machines developed by the institute, which should shorten considerably the cycle for the introduction of new developments.

In light of the decree "On Know-How Gained by Collectives of Enterprises of the Ferrous and Non-Ferrous Metallurgy and Chemical Industries Relating to the Utilization of Secondary Fuel and Energy Resources" adopted by the CPSU Central Committee, an extensive program of work has been planned, aimed at improving the utilization of secondary energy resources at enterprises of the republic's ferrous metallurgy industry. More than 95 percent of combustible secondary energy resources in the republic are from enterprises of the ferrous metallurgy industry and of this about 92 percent are utilized, which is equivalent to 21 million tons of conventional fuel. The losses here, equaling about 1.3 million tons of conventional fuel, could be utilized completely. Plans have been made to carry out the construction of turbine generators and steam power plant boilers at the Yenakiyevo, Kramatorsk and a number of other metallurgical plants for the purpose of totally eliminating above-norm losses of blast furnace gas. It is necessary to speed work which would be conducive to the total utilization at the Nikopol', Zaporozh'ye and Stakhanovskiy ferroalloy plants of the flue gas of ferroalloy furnaces, which, in spite of its high calorific value, is being utilized by only 25 percent.

Considerable potential in economizing on fuel lies in improvement of the utilization of thermal secondary energy resources, whose yield at ferrous metallurgy enterprises is estimated at 5.3 million tons of conventional fuel per year and whose utilization equals about 40 percent. Four hundred and nine heat recovery plants, 53 of which were put into service during the years of the 10th Five-Year Plan period, were in operation in 1980 at enterprises of the Ukrainian SSR Ministry of Ferrous Metallurgy. For the purpose of the fuller utilization of thermal secondary energy resources it is necessary to expand and speed the construction at metallurgical plants of new waste-heat boilers, recuperators, units for evaporative cooling of elements of metallurgical furnaces, converter gas coolers, and units for the dry quenching of coke, as well as to reconstruct and modernize a number of existing recovery plants. Calculations have demonstrated that the capital investment for one ton of conventional fuel obtained on account of the utilization of secondary thermal energy resources is four- to sixfold lower than for that obtained on account of the development of coal mining. In connection with this it would be advisable to earmark for special purposes, from the overall limits of capital investment for development of the fuel industry, capital for the construction of heat recovery plants, making them equal in importance to fuel supply projects. This would make it possible to speed considerably the construction of heat recovery plants and to utilize more effectively the available secondary energy resource potential. In the 11th Five-Year Plan period it will be technically feasible to increase the utilization of thermal secondary energy resources by approximately one million tons of conventional fuel at the republic's metallurgical enterprises on account of putting into service and improving the utilization of existing heat recovery plants.

Meanwhile in ferrous metallurgy there are still no technical solutions for the recovery of a considerable amount (about 1.2 million tons of conventional fuel) of secondary energy resources. This includes the utilization of the heat of coke gas, of metallurgical slag, of heat from the burning of converter gases in power plants, etc. In this area it is necessary to speed the performance of scientific research and experimental design work relating to the creation of methods and equipment making it possible to utilize this potential.

A comprehensive territorial program should be developed for maximum utilization of the secondary energy resources of metallurgical enterprises taking into account furnishing them to the fullest extent with heat recovery equipment and maximum coverage of the heat requirements of enterprises, residential districts and other industrial installations of the region, as well as the creation on this basis of vegetable hothouse combines. As a first-priority measure the procedure should be established whereby the planning and construction of installations for the production of heat energy at industrial enterprises are permitted only with the substantiated impossibility of utilizing secondary energy resources for heat supply purposes.

In 1981-1985 further development of the ferrous metallurgy industry must proceed mainly along the line of radical improvement in the quality and an increase in the output of effective kinds of metal products. This trend makes it possible to satisfy the demand for metal products with the least expenditure of public labor, provides a considerable savings in metalworking and improves the performance indicators of machines, equipment and metalwork. In light of these requirements considerable work is planned in the republic's ferrous metallurgy industry in keeping with the "Metall" [Metal] republic special-purpose combined scientific and technical program.

One major trend in improving the quality of rolled products, pipes and metalware is the development and improvement of the grade assortment of steel produced. The production of metal products made of low-alloy grades of steel, whose strength characteristics are 25- to 30-percent higher than similar carbon steel, will increase 1.7-fold during the years of the 11th Five-Year Plan period, and of alloy steel 1.5-fold, and the production of metal products made of high-quality grades of carbon steel will be expanded further. Furthermore, scientific research work is being expanded considerably on the development and mastery of the production of more effective and economical grades of steel, primarily of low-alloy and alloy steel utilizing boron, titanium, vanadium in combination with nitrogen, niobium and rare earth and other elements. On this basis the production of semikilled low-alloy steel, which increases by 8 to 10 percent the output of suitable metal with a 3- to 7-ruble/ton-lower cost of rolled products, should receive extensive development.

The production of steel employing out-of-the-furnace methods of treating the molten metal with synthetic slag, a vacuum and inert gases will increase 2.5-fold during the 11th Five-Year Plan period. This necessitates the development on the part of the machine building industry of the production of special equipment and the more extensive introduction of production experience already gained at a number of plants. The especially high requirements for the purity of metal and the accuracy of its performance characteristics from the quarter of the vigorously advancing areas of new technology have caused the rapid pace of development of the electroslag, vacuum arc, electron beam and other methods of remelting metal.

In addition to improvement of the quality characteristics of metal produced, a great role in reducing the consumption of metal and labor costs in machine building in the manufacture of machines, as well as in improvement of their performance properties, is played by expansion of the assortment of rolled products, pipes and metalware and mastery and expansion of the production of advanced types of them. Improvement of the rolled product assortment of general-purpose shapes, which make up about 70 percent of the total of rolled products supplied, will have the goal of determining intelligent assortment series, of improving the accuracy of geometrical dimensions and of the more effective distribution of metal over the cross section of shapes (beams, channels and angles). In keeping with these trends the development of new all-Union State standards is planned for a series of kinds of rolled products for this purpose. Several mills will be equipped with rigid stands and automatic systems for checking and controlling the geometrical dimensions of rolled products. The technology of the hot sizing of general-purpose section steel (circles, squares, etc.) should win introduction in industry, which will make it possible to increase considerably the precision of their geometrical dimensions and to produce an 8- to 10-percent savings of metal in the machine building industry. It is necessary to speed work on introducing the supplying of general-purpose rolled products made of carbon steel in accordance with GOST [All-Union State Standard] 380-75, with a differentiated classification of actual strength into two or three classes, which can produce a 12- to 15-percent savings of metal in welded constructions.

The goal will be set of considerably expanding the assortment and total output of special-purpose hot-rolled shapes, which are used in machine building and construction in the series production of machines and metalwork, reducing the consumption of metal by 30 to 60 percent and labor costs 1.5- to twofold. The section mills at the Makeyevka, Krivorozhstal', Donetsk, Dneprovskiy imeni Dzerzhinsky and Kramatorsk plants will be reconstructed and modernized for this purpose. Stands, surface conditioning and finishing equipment and thermal equipment are to be installed.

Under the heading of the most economical kinds of rolled products are die-rolled sections with a cross section which varies along their length, saving 30 to 50 percent of the metal and in a number of cases increasing labor productivity 8- to 10-fold in the fabrication of parts. In the 11th Five-Year Plan period at the Dnepropetrovsk Plant imeni Petrovskiy is planned the construction of a "550" mill designed for producing sections of this type by the longitudinal rolling method, as well as the second phase of the "250" mill at the Dneprovskiy Plant imeni Dzerzhinskiy for rolling hollow (of the thin-walled tube type) car axles by the helical rolling method.

Cold-bent shapes, which make it possible to reduce the consumption of metal by 25 percent and labor costs for consumers by approximately 10 rubles per ton, will receive further development of their assortment and production volume. For this purpose capacities are being increased on account of modernization at the Zaporozhstal' Plant's shop and new more effective thin-walled, perforated, closed and other complicated types of cold-bent shapes will be mastered.

The production of heat-hardened rolled products and pipes, with a 1.5- to twofold increase in strength, will increase 2.2- to 2.5-fold during this period on account of the construction of large departments for the thermal hardening of rails at the Azovstal' Plant and of plate steel at the Zhdanov Plant imeni Il'ich and the expansion of thermal hardening equipment at the Krivorozhstal', Makeyevka, Kommunarsk, Novomoskovsk Pipe, Nikopol' Yuzhnotrubnyy, etc., plants.

One of the main trends in improving the quality of metal products is the expansion of the production of rolled products, pipes and metalware with protective coatings, which makes it possible to extend the service life of metal products, thus saving a great amount of public labor. In the 11th Five-Year Plan period the aim is to put into operation the second phase of the metal-base laminate department at the Zaporozhstal' Plant, a plastic coating department for large-diameter gas pipes at the Khartsyzsk Pipe Plant and a number of sections for protective coatings for metalware. The method of thermal-diffusion chromizing of sheet metal and pipes created by the UkrNIIspetsstal' [Ukrainian Scientific Research Institute of Special Steels, Alloys and Ferroalloys] Institute will be introduced in industry and fuller utilization will be made of the potential of existing capacities for the production of metal products with protective coatings at the Zhdanov imeni Il'ich, Zaporozhstal', Nizhnedneprovskiy Metal Products, Druzhkovka Metalware and Nikopol' Yuzhnotrubnyy plants. As a result, during this period the output of metal products with protective coatings will increase 4.4-fold.

The production of combined metal products consisting of two to three grades of steel, alloys or metals which most meet the conditions for utilization of their various parts will receive further development. There will be an increase in the production of two-ply sheet metal consisting of construction grades of steel in combination with stainless and other types of steel and alloys with special properties at the Kommunarsk and Zhdanovsk imeni Il'ich plants, of clad metal pipes (steel in combination with bronze, copper, titanium and other metals) with the construction of a new shop at the Dnepropetrovsk Pipe Plant imeni Lenin, and of clad metal rounds for machine building with the construction of a new shop at the Kommunarsk plant. The output of metal products of this type will increase three- to 3.5-fold during the five-year plan period. Research on the creation of other kinds of combined metal products will be expanded.

The goal will be set of considerably expanding the production and assortment of many advanced and economical kinds of steel pipes and metalware which make possible a savings of metal and technical progress in industries using them. The production of a series of new high-strength drill and drive pipes with new threaded connections will be mastered and their output expanded, and of shaped construction and high-precision pipes and pipes made of various kinds of alloy steel for machine building. The plan is to arrange for the production of special tubes for the furniture industry, of tubes made of nickel-free stainless steel for the sugar industry, which will extend 8- to 10-fold the service life of evaporators, of multilayer electrically welded pipes for gas lines, of thin-walled compressor and many other new kinds of tubes needed by the national economy.

The total output of individual kinds of metalware for interindustrial applications will increase 1.3- to 1.6-fold at specialized plants of the ferrous metallurgy industry, which will produce a savings of metal of up to 30 percent, will reduce labor costs two- to threefold and requires four- to fivefold less production space as compared with their fabrication by the consumer. The production and assortment will be expanded for special kinds of wire, mesh, advanced grades of welding electrodes, powder wire and ribbon for surfacing operations, new designs of more durable cable, and sized steel and fastening articles for machine building, and many new more effective kinds of metalware will be mastered.

Further improvement of the quality and expansion of the assortment of metal products require a number of economic management measures. It is necessary to create a procedure for taking into account the quality level of metal products in determining the effectiveness of capital investment and estimating the output-capital ratio in the industry. Indicators and methods of planning the production and distribution of metal products taking into account their quality characteristics should be improved, along with price formation and economic incentive systems, and a number of other measures must be carried out, aimed at improving the quality and expanding the assortment of metal products.

The big problems confronting the republic's ferrous metallurgy industry in the 11th Five-Year Plan period require further improvement of the efficiency and quality of work in all production units, mobilization of the internal potential for improving the work of the industry and each enterprise, shop and crew, more precise engineering and economic planning estimates and intensification of organizing work at all levels of management.

COPYRIGHT: IZDATEL'STVO "RADYANS'KA UKRAYINA", 1981

8831
CSO: 1842/140

UDC: 621.74.002.6:621.74.043:669.715

PRODUCING CASTINGS FROM ALUMINUM ALLOYS BY IMMERSION OF THE CHILL MOLD IN THE MELT

Moscow LITEYNOYE PROIZVODSTVO in Russian No 1, Jan 81 pp 22-23

KOVRIZHNYKH, N. I., candidate of technical sciences, GUSAROV, V. D.,
PIVOVAROV, V. K., GROMOV, L. K. and UBUSHAYEV, A. U., engineers

[Abstract] Casting by immersing the mold in the melt achieves high quality of castings with low consumption of metal. The essence of the process is that the mold is filled when immersed through feeder valves in its bottom and sides. The mold is not moved until the casting has completely solidified inside it. The heat-accumulating capacity of the mold allows solidification to occur, with the casting fed through the feeder valves, which must be designed to be of the proper size. Series production castings are produced with a total mass of 2.1 kg and solidification time 3 minutes. Tests have shown that the process can be fully automated if sand cores are not used.
[130-6508]

UDC 669.017.3:669.14.018.44

PREDICTING INFLUENCE OF STRUCTURAL FACTORS ON MECHANICAL PROPERTIES OF HIGH-TEMPERATURE ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 81 pp 16-20

LOGUNOV, A. V., PETRUSHIN, N. V., KULESHOVA, Ye. A. and DOLZHANSKIY, Yu. M.,
All-Union Scientific Research Institute of Aviation Materials

[Abstract] A mathematical relation is found for the way that some mechanical properties of high-temperature alloys of the MAR-2000 type depend on structural factors. On the basis of experimental data, regression equations are formulated for the temperature of complete dissolution of the γ'-phase as a function of chemical composition of the alloy, and also equations that describe the influence of chemical composition on characteristics of the structure and heat resistance of nickel alloys. A correlation is found between the temperature of total dissolution of the hardening γ'-phase in the solid solution and the durability of high-temperature nickel alloys. In nickel alloys that contain approximately the same amount of highly dispersed particles of γ'-phase (50-60%) the alloys with maximum temperature of total dissolution of the γ'-phase have the greatest durability, ultimate strength and relative longitudinal extension of nickel alloys at 20°C. Analysis of these expressions shows that alloying leading to simultaneous segregation of a large number of excess phases reduces durability at 1100°C, ductility at 20°C, and increases strength at 20°C. The resultant models can be used to predict the influence of structural factors on mechanical properties of alloys of this type. Figures 1; references 17: 14 Russian, 3 Western.
[133-6610]

POWDER METALLURGY

UDC: 621.762

CORROSION RESISTANCE OF POROUS FIBER MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 81
(manuscript received 25 May 80) pp 54-57

KARPINOS, D. M., CHEKHOVSKIY, A. A., RUTKOVSKIY, A. Ye., PODSOSONNYY, V. I. and IVANCHUK, A. A., Institute of Problems of Material Science, Ukrainian Academy of Sciences

[Abstract] A study is made of the corrosion of porous gas permeable fiber materials based on type 03Kh18N9T steel when exposed to sea water. Specimens used were disks 30 mm in diameter and 4 to 5 mm thick, with porosities of 22 to 48%. The specimens were exposed to the air, precipitation and salt spray in the air. The corrosion rate was determined by the rate of increase in weight as corrosion products accumulated. The corrosion rate was found to be slow, 2 on a scale of 10, meaning that the products are in the "very resistant" classification. Figures 1; references 12: all Russian.
[127-6508]

UDC: 621.762:669.295'24

PHASE COMPOSITION AND PROPERTIES OF SINTERED SPECIMENS PRESSED FROM POWDERED MIXTURE OF NICKEL AND TITANIUM

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 81
(manuscript received after revision 30 Nov 80) pp 39-42

AKSENOV, G. I., DROZDOV, I. A., SOROKIN, A. M., CHERNOV, D. B. and ATYAKSHEV, Yu. A., Kuybyshev Aviation Institute

[Abstract] The production of titanium nickelide on the industrial scale is rather difficult and expensive. Therefore a study was made of the production and properties of powdered titanium nickelide produced from a mixture of an equiatomic composition of powdered nickel and powdered titanium. The mixtures were prepared in a laboratory mixer, pressed at 300 to 1200 MPa, producing cylindrical and

prismatic specimens which were sintered in a vacuum of $6.65 \cdot 10^{-5}$ Pa at 600 to 1100°C for 2 to 20 hours. The cylindrical specimens were deformed and were found to have good ductility, not failing under 30% uniaxial compression. Specimens deformed, then annealed at 700°C in a vacuum for one hour manifested some shape memory. Figures 3; references 5: all Russian.
[127-6508]

UDC: 621.762.5

OPTIMIZING PROCESS OF HOT PRESSING OF VK6 HARD ALLOY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 81
(manuscript received after revision 27 Apr 80) pp 30-34

BRONSHTEYN, D. Kh., SIMKIN, E. S., PANICH, A. N. and TSYPIN, N. V.,
Institute of Superhard Materials, Ukrainian Academy of Sciences

[Abstract] The authors' institute has undertaken a combined study of the regularities of hot pressing of hard alloy powders and the properties of powder alloys. The variation and properties of hot pressed hard alloys as a function of technological parameters and the selection of optimal process conditions were performed by the method of mathematical planning of experiments. The hardness, density, coercive force, flexural strength and impact toughness were determined by the standard methods. Microstructural analysis was performed on a microscope. The tungsten content was determined by the magnetic method. The optimal conditions for hot pressing of a tungsten monocarbide-based alloy with 6 mass % cobalt were determined. The optimal properties of hard alloys manufactured by hot pressing are achieved by producing a fine grained structure, requiring regulation of the dissolution of tungsten carbide in the cobalt. References 12: all Russian.
[127-6508]

UDC 621.762.669.295

SODIUM-THERMAL PRODUCTION OF TITANIUM POWDERS OF CHLORIDES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 81
(manuscript received 17 Apr 80) pp 1-5

ALEKSANDROVSKIY, S. V., BERDNIKOVA, L. M., LUKASHENKO, G. S., PINAYEV, Ye. N.
and SNISAR', G. P., Leningrad Mining Institute

[Abstract] The technology and apparatus for production of sodium-thermal titanium powders on an experimental industrial scale was investigated. Wastes and lower grades of titanium, the spent electrolyte from magnesium production, titanium

tetrachloride and metallic sodium were used as the initial materials. The experimental industrial installation was a reactor to produce lower titanium chlorides, a proportioning filter and sodium purification and reduction apparatus. Titanium tetrachloride reduced by the two-stage version produces metallic titanium in the form of a spongy mass consisting of fine crystals with high specific surface. The titanium powders produced during sodium-thermal reduction of the lower titanium chlorides have a lower impurity content. Sodium-thermal reduction of titanium tetrachloride produces powders with more developed surface and these powders are characterized by increased impurities and hardness. The experimental knots of titanium powders yielded the most positive results in manufacture of porous tape and refractory compounds by the self-propagating high-temperature synthesis method. Figures 2; references 4: all Russian.
[137-6521]

UDC 669.245.004.74:620.18

INVESTIGATING BREAKDOWN OF EP-701P REFRACTORY ALLOY BY THERMAL MICROSCOPY METHOD

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 81
(manuscript received 3 Jan 81) pp 54-59

YEZHOV, A. A., SHVARTS, V. I., POPOVA, L. Ye., GERASIMOVA, L. P., DAVYDOVA, V. A., KOTOV, V. F. and YEREMENKO, V. I., Moscow

[Abstract] The structural features of deformation and failure of EP-741P refractory alloy produced by the powder metallurgy method were investigated by thermal microscopy and scanning electron microscope as a function of the purity of the initial material for oxygen content. The alloy was produced from powder by hot isostatic forming in a quasi-molten medium and in a gasostat. EP-741P refractory alloy deforms primarily at 750°C by the shear mechanism through sequential formation of slip bands and intergrain slip. Deformation along the initial boundaries of the powder particles increases with oxygen content above 0.01 percent. Failure occurs through the boundaries of the powder particles at low stress and local deformation. Figures 5; references 3: 2 Russian, 1 Western.
[137-6521]

UDC 548.39

ENERGY OF INTERLAYER INTERACTION AND RELATIVE STABILITY OF DIFFERENT CRYSTALLINE MODIFICATIONS OF GRAPHITE-LIKE BORON NITRIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 81
(manuscript received 17 Apr 80) pp 87-91

DANILENKO, V. M., KURDYUMOV, A. V. and MEYKE, A. V., Institute of Problems of Material Science, Ukrainian SSR Academy of Sciences

[Abstract] The energies of interlayer interaction and interlayer distances were calculated in intermediate graphite-like structures formed in boron nitride crystallization and in polymorphic transformations. The results of calculation were compared to experimental data and showed a new ADAD structure. The conditions for changing this structure to AA'AA' structure were investigated. AA'AA' structure has the minimum energy and AAAA structure has the maximum energy, with the difference in energy being determined by the contribution of Coulomb interaction. The AA'AA' structure is the most widely distributed and the only stable phase at low pressures. The ADAD modification has the highest Van der Waals interaction energy due to the energy equivalents of all its lattice nodes. Each D layer must be shifted to vector b with rotation by 60 degrees to transform ADAD structure to stable AA'AA' structure. Figures 2; references 9: 7 Russian, 2 Western.
[127-6521]

UDC 621.912-432.2

ABRASIVENESS OF TITANIUM CARBIDE AND TITANIUM CARBONITRIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 81
(manuscript received 16 Jun 80) pp 78-81

ARBUZOV, M. P., MOSHKOVSKIY, Ye. I. and LYASHCHENKO, A. B., Institute of Problems of Material Science, Ukrainian SSR Academy of Sciences

[Abstract] The abrasiveness of titanium carbide and carbonitride powders in grinding ShKh-15 and U-10 steels in the delivery state was investigated. Abrasive powders manufactured by pulverization and also titanium carbide and titanium carbonitride powders manufactured by pulverization of ingots produced by melting titanium carbide and titanium carbonitride in the copper water-cooled crystallizer of an arc furnace with nonconsumable electrode were used. Titanium carbide powders produced by SVS and melting methods have essentially the same abrasiveness when grinding glass and have greater abrasiveness than synthetic corundum (by a factor of 1.3-1.35). The titanium carbide and titanium carbonitride powders are superior to synthetic corundum when machining steels during the first 5 to 10 minutes of operation. Titanium powders reduce the surface roughness and are recommended as grinding and polishing powders for machining steels. Figures 4; references 7: all Russian.
[127-6521]

UDC: 669.295

INCREASING HOMOGENEITY OF A TITANIUM SPONGE BLOCK IN TERMS OF CHLORINE IMPURITY

Moscow TSVETNYYE METALLY in Russian No 5, May 81 pp 55-56

CHEREPANOVA, Ye. A., MAL'SHIN, V. M., GULYAKIN, A. I., MUSHKOV, S. V. and PERESADA, Z. V.

[Abstract] Based on the specifics of formation of the structure of titanium sponge in various stages of the process of reduction, the authors studied reduction conditions with a change in the rate of $TiCl_4$ feed in the first and second stages of the process. Two processes were performed with 320 and 180 kg/hr $TiCl_4$. Thirty-five sponge specimens were taken from the central axis of each block by drilling after separating it into two equal parts at mid-height. The chlorine impurity was distributed more uniformly in the process with input of 180 kg/hr $TiCl_4$: the upper half of the block contained an average of 0.05% Cl, the lower half 0.03% Cl. The figures for 320 kg/hr were 0.19% and 0.07% Cl. Experiment showed that the formation of the structure of the block during reduction has a significant influence on the residual content of chlorine in the block. It was found that the homogeneity in terms of chlorine impurity can be improved by decreasing the feed rate of titanium tetrachloride during the second stage of the process to 180 kg/hr with $K_{Mg}>40\%$. Figures 1; references 4: all Russian.
[113-6508]

UDC 669.17:621.785.16

KINETICS OF DECOMPOSITION OF THE METASTABLE β-PHASE IN VT15 TITANIUM ALLOY DURING AGE HARDENING

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 25, No 3, Mar 81
(manuscript received 17 Jun 80) pp 243-246

BODYAKO, M. N., corresponding member, BSSR Academy of Sciences, GORDIYENKO, A. I., DYMOVSKIY, A. S. and ZHURIN, V. A., Physical-Technical Institute, BSSR Academy of Sciences

[Abstract] Hardness tests, X-ray analysis, and examination with the electron microscope were used in the title study. The alloy was composed of 28% Al, 7.2% Mo, 10.1% Cr, 1.2% Zn, and the remainder Ti. The samples were heated to 850°C or 1000°C at 100°C/sec, then aged at 300°, 400°, or 450°C for 15 minutes to 48 hours. The β-phases obtained by heating to 1000° were both more homogeneous and more stable toward subsequent disintegration in comparison to those heated to 850°C. During the hardening at 300°C, the lattice parameters and hardness remained virtually unchanged over the 48 hours. At 400°C, the hardness increased and the β-phase parameters decreased during the first 6 to 12 hours. After 24 hours, the X-ray diffraction data indicated the presence of traces of the α-phase, which increased to significant amounts after 48 hours. At 450°C, the hardness as well as the number and size of the α-phase particles increased with increasing time and at a faster rate than for the 400°C samples. The β-phase particles have a smaller size and higher density than the α-phase. These differences also exert a significant influence on the plastic properties of the materials. Figures 2; references 8: all Russian.
[109-12027]

TRANSPORT PROBLEMS IN OPEN-PIT ORE-MINING OPERATIONS

Kiev RABOCHAYA GAZETA in Russian 2 Jun 81 p 2

[Article by F. Alekseyev, deputy director of the Scientific Research Ore Mining Institute, candidate of technical sciences: "Metal is the Bread of Industry" (Krivoy Rog, Dnepropetrovskaya Oblast)]

[Text] As is well known, metal starts with ore. And if we say that, today, the national economy needs more and more metal, the question of ore in itself must be posed more acutely. This, by the way, is clearly and definitely stated in the basic directions for the economic and social development of the country in the coming 10-year period -- to provide advanced development of the raw material base of ferrous metallurgy.

One can hardly talk about advanced development: the rates of development of the raw material base do not meet the requirements of metallurgy lately. A little later on I will prove this by calculations. But now I want to state: a further increase in mining ore in the long run will be due to working deposits with poorer ores and ores deposited under complex geological-mining conditions. This presents additional difficulties. Besides complex "geology," the constantly increasing depth of underground and open-pit mines should be kept in mind. Also, that in open-pit mining, the depth has a more pernicious effect on technical-economic indicators than in underground mines.

The situation in the open-pits of mining-enriching combines of the republic is very strained. It didn't happen today or yesterday. For many years in a row, alarming articles on this have appeared in print, including the RABOCHAYA GAZETA. However, there were many calming replies from the UkSSR Minchermet [Ministry of Ferrous Metallurgy]: we say that measures are being taken and will be taken in the future to overcome the lag in stripping.

But what is the actual situation? It would be unjust to say that the ore miners and the Minchermet of the republic were idle. But the requirements in metallurgical raw materials have increased year after year. How were they satisfied? According to the situation in January 1979, the shortfall in stripping amounted to about 190 million cubic meters, while at the start of this year, the shortfall was already 245 million cubic meters. As a result, the combines were about 6 million tons of concentrate short in their supplies to metallurgists last year.

This cannot be called an oversight. The ministry knew about this discrepancy and even used it in the plans. In the years indicated, the difference between the scientifically substantiated actual stripping requirements and the approved plans was 56 million cubic meters. That is, 76 million tons were required and 20 million tons were planned.

Problems with transport are usually given as the main reasons for the situation in the pits. It is impossible to provide transportation for the constantly increasing volumes of rock and ore from the points of loading to unloading: speaking of ore, from the stope to the enriching factory; if it is rock -- from the stope to the dump.

Specialists have different opinions on the solution of this problem. Some think that the pits should be changed over to cyclic-flow line technology (TsPT). But let us take a look at this from the technical and economic viewpoints. To create and assimilate new machines to realize TsPT would require a very long time -- no less than 10 years. In fact, it would be necessary to either reorient the existing planning-design organizations to develop the designs of these machines, or create new organizations. As far as the assimilation of the production of new machines at existing enterprises is concerned, it can be most definitely stated that it is impossible to expect a rapid positive solution. The simple and serious reason for this is that the assimilation of new machines not only does not eliminate, but does not even reduce the requirements for machines already being manufactured in series. It means that new enterprises will be required anyhow to manufacture heavy conveyors, especially strong transportation belts, self-propelled crushing machines, screens, reducers for various electrical machines and other equipment. And this is actually not economical and will take a long time.

If one is to judge by a number of decisions of the UkSSR Minchermet, it proposes to change all iron ore combines over to cyclic-flow line technology.

I dare to question the opinions of cyclic-flow line technology proponents. This is not a technology, but just an insert in the transport arrangement for hauling out ore and rock. The ore and rock must be transported from the point of loading to the final point of unloading. As stated previously, the ore -- to the factory and the rock -- to the dump.

As an example, let us follow the route of the ore from pit No 3 of the Novokrivorozhskiy Mining-Enriching Combine where construction and other work on the creation of such a cyclic-flow line technology must be completed at a cost of about 25 million rubles. The ore at the stope will be loaded into a dump truck, then transported to the TsPT receiving point,where it must be unloaded and crushed. (Why? When at the factory it again goes into a crusher?) Further, it is loaded on the conveyor through bunkers and will be sent to the surface near the pit where, by means of fairly complex devices, it will be unloaded at an especially built warehouse. A RR station is being built at the warehouse where excavators will load RR cars and the ore, finally, will arrive at the factory. The problem of taking the rock out of low levels is, in this case, not solved at all.

Some people suggest building the conveyor right to the factory. But at the same Novokrivorozhskiy Combine the distance will remain the same as over the RR. However, the cost of transport by conveyor is over 5 kopecks per ton-kilometer, while transport by RR will cost 1.2 to 1.3 kopecks.

Cyclic-flow line technology is already in use at the pits of the Inguletskiy and the Anovskiy Northern mine-enriching combines. This not only has not improved the situation there, but to the contrary, has aggravated it. Why? The productivity of the TsPT complexes is no greater than 18 million tons per year, while the pits produce 70 to 80 million tons of ore and rock. This means that to provide normal operation at each pit, three or four more such complexes must be built.

For a rational solution of the transport problem at open-cut pits, our Scientific Research Ore Mining Institute proposes working large pits to the maximum depth by using sloped RR tunnels in combination with ore chutes.

The advantages of this are obvious. First, with this technology it will not be necessary to develop new equipment: transportation facilities -- propulsion machines and dump trucks are series manufactured by our industry. Secondly, the most expensive truck transportation of ore and rock within the pits will be reduced from 2-3.5 to 0.5-0.9 kilometers and the trucks will move primarily over horizontal areas of the working ledges with the rise or descent no greater than one-two levels (15-30 meters). Therefore, the need for dump trucks is reduced several times and there will be no need for trucks with load capacities greater than 75 tons. Thirdly, the productivity of the rolling stock will increase 1½ to 2 times due to its accelerated loading from the ore chutes, and because the trains move over routes without intersecting train movements.

Further, due to the high transit capacity of the tunnels, not only will the entire volume of ore and rock be taken out of deep levels, but the stripping shortfall will also be eliminated. It will be possible to use, to a considerably greater degree, the most economical and accessible form of power -- electrical, and sharply reduce the use of scarce diesel fuel.

A number of other arguments can be used in favor of the RR tunnel method of transporting the mined mass. Among them, one of the most important is the elimination of repeated rebuilding of the system of stripping and transporting in pits to the maximum depth and even when changing over to underground mining in the deep part of the deposit. It will only be necessary to deepen the tunnels and prepare new pit levels of the mine shaft type.

The present pits are practically in a stage of constant reconstruction. Thus, at the Pervomayskiy pit of the Severnyy Mine-Enriching Combine, a reconstruction of the stripping and transport systems has been in progress since 1973. The main link of this reconstruction is tunneling additional trenches to a depth of 60 meters. The designer concept at that time was that this would make it possible to work the pit to a depth of 300 meters. The reconstruction cost was about 70 million rubles. However, since this reconstruction did not solve the problem of bringing the ore and rock out of the deep levels, a plan for new reconstruction has now been approved. Its cost is already estimated at 137 million rubles. And the cost will grow and grow.

In 1973, the "Yuzhgiproruda" Institute completed on an assignment from the USSR Minchermet a technical-economic substantiation of rebuilding this pit to a depth of 300 meters using tunnels at a cost estimated at 111 million rubles. Compare this with the present investments for both reconstructions -- 70 plus 137 million rubles. If the "Yuzhgiproruda" plan had been followed, then first, it would have been completed long ago since the schedule was determined at 5 years, and secondly, repeated reconstructions would not have been needed.

Of course, tunneling is an expensive measure. We understand that the situation with capital investments is difficult. But any other variations of stripping and transport are immeasurably more expensive, and they interfere with the normal pit operation. But not doing it requires the investment of money and fairly frequent reconstructions on which capital investments several times greater than the construction of tunnels are required. In this case, economics can in no way be economical.

It is difficult to understand why the ministry rejects the plan proposed by the NIGRI [Scientific Research Ore Mining Institute] scientists in 1971. They reject, but neither do they propose another constructive solution, proceeding along the route of approving reduced stripping volumes and aggravating the situation further in the iron ore subsector. Why are we delaying the introduction of RR transport along sloped tunnels? Sometimes we hear an explanation: experience is lacking. But what is unknown here? An access ramp is being operated successfully at the Korkinskiy coal open-cut in the Chelyabinskaya Oblast. There is also experience abroad.

As we see it, the way out of a difficult situation that exists at a number of pits can only be the introduction of the most productive and economical transport -- RR transport through sloped tunnels, first to the working zone of the pits and then also under the pits. This is the most realistic, the most economical and the quickest way.

2291
CSO: 1842/143

UDC: 669.052

SEEKING COMPREHENSIVE UTILIZATION OF RAW MATERIALS IN METALLURGICAL INDUSTRY

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 2, Mar-Apr 81 pp 3-13

[Article by A. I. Manokhin, N. A. Vatolin, and V. A. Reznichenko: "Resolving the Problem of Comprehensive Utilization of Raw Materials in Metallurgy"]

> [Text] "In order to protect and preserve the sources of our raw materials, observance of scientific-technical rules and efficient exploitation are essential."*

As a result of scientific and technological achievements in the postwar period techniques were developed for obtaining practically all presently known metals and a large number of alloys based on these metals, and the properties of these metals and alloys were studied, which led to substantial changes in metallurgical production. Quantitative production growth (especially production of mass consumption metals: steel, aluminum, magnesium) was accompanied by change in the qualitative structure: facilities were built for the production of titanium, a new structural metal, reserves of which in the earth's crust are the fourth most abundant, after those metals named above, and rare metals (rare-earth, refractory, and radioactive, including uranium, silicon, and germanium), which not only changed the direction of development of this country's power industry (nuclear and solar power engineering) but also created the foundations of materials science for electronics, radioelectronics and other new branches of technology, which guaranteed our successes in the development of computers, space exploration, special areas of defense technology, etc.

The production of metals (metallurgical processes) advanced to a qualitatively new level during this period. Metallurgical processes, however, are merely one of the foundations of metallurgy; others -- utilization of raw materials (raw materials base) and energy (energy base) -- lag significantly behind in their development, especially if one considers requirements and capabilities being opened up by scientific research efforts in the area of development and improvement of production. The energy problem, as stated by Academician A. P. Aleksandrov, President of the USSR Academy of Sciences, potentially will be solved on the basis of utilization of nuclear and thermonuclear power engineering [1], while the raw materials problem will be solved on the basis of comprehensive utilization of mineral resources [2].

---

* V. I. Lenin, "Report at 11 April 1921 Meeting of the Communist Faction of the All-Union Central Trade Union Council," "Soch." [Writings], Vol 32, page 386.

Growth in consumption of metals is steadily advancing in the era of R&D, which dictates the necessity of perfecting ways to achieve their efficient utilization (decreasing weight and increasing reliability of machinery, expanding the applications of powder metallurgy, and reducing the amount of waste in processing metals*) and increasing the recovery of metals from raw ore, by means of its full and comprehensive utilization. These trends are becoming increasingly more obviously critical in connection with exhaustion of world raw ore resources suitable for efficient processing by current industrial processes in ferrous and nonferrous metallurgy [3-5]. On the background of acute crises -- economic-ecological and others -- which are shaking the capitalist world, the specter of a raw materials crisis is looming on its horizon with increasing frequency and distinctness, a crisis fraught with no less ominous consequences than any other cataclysm. This situation is being helped along by the fact of a distinct focus by companies and corporations on the production of specific metals, which determines high demands on raw material pertaining to content of the principal metal and processing properties, since this guarantees productive operation of metallurgical facilities and production profitability. There exist calculations, performed with a sufficiently high degree of scientific reliability, which indicate that proven world reserves of many commercial-grade ores of principal metals, even with a minimal level of consumption growth, will be exhausted within the next century. If we take the current U.S. level as the maximum level of world per capita metals consumption -- the United States, with 5 percent of the world population, consumes 40 percent of world output of molybdenum, 45 percent of aluminum and 33 percent of copper -- world copper supplies will be sufficient for only 6 years, molybdenum for one year, etc [6].

The Soviet Union, with its wealth of mineral resources, is not presently threatened by a raw materials shortage. But at the same time it is already obvious today that if during the next hundred years present industrial production processes are retained, with a clear-cut branch and subbranch metals focus, with high demands on initial raw materials, the threat of exhaustion of supplies of mineral raw materials will become a reality. We know, for example, that in the last seven years capital investment per ton of produced raw materials has increased 2.5-fold, but USSR Minchermet [Ministry of Ferrous Metallurgy] does not always and at all locations have an adequate quantity of costly raw materials [3].

Today as much is being invested in the extractive industry to maintain the achieved level of metals production as was spent in the past on rapid growth in the rate of production. The raw materials balance has become tough for nonferrous metallurgy, the chemical industry and the power industry in the Center and Urals. Of course these difficulties can be eliminated by stepping up development of Eastern sources. It is more advisable, however, to exploit Siberian mineral resources locally, developing regional industrial complexes [7]. Hauling ore concentrate from the East can alleviate the raw materials situation in the West, but establishment of flows of raw materials on such a transcontinental basis is scarcely the optimal solution to the problem.

---

* Societal production costs are increasing by 12 billion rubles annually due to high materials requirements and other deficiencies, including 8-9 billion rubles by increasing the weight of machinery, and 3-4 billion rubles by an increase in the quantity of metal waste.

There exist other methods of achieving a regional and fundamental solution to urgent and long-term problems connected with raw materials difficulties. These include first and foremost reduction in mineral resources requirements. The ways to achieve this are well known. As already indicated, the principal way is to reduce the metal requirements of industry by developing economical designs and increasing the durability and corrosion resistance of metals products, especially by application of coatings, increasing the strength of materials, practicing rigid conservation of metals at all stages of metals utilization and product manufacture, and the adoption of such efficient processes as powder metallurgy not only for manufacturing finished products but also semimanufactures, including rolling-mill stock (mass powder metallurgy). Of considerable importance is intelligent replacement of metal by other equally or more durable materials, and efficient utilization of scrap and metal waste.

In the latter case not only are potential sources of metals drawn into production in the form of recyclable products, but there are also considerable possibilities of achieving savings in energy. According to official figures, for example [8], scrap is estimated to comprise more than 30 percent of total metals requirements in the United States, with energy savings from utilization of scrap close to 25 percent of total energy outlays for producing metals from ore. This is due to the fact that the cost of producing a ton of primary metals is substantially greater in comparison with their subsequent utilization (for example, 36 times greater for magnesium, 20 times for aluminum, 10 times for nickel, 4 times for zinc, etc).

If one considers that modern civilization is based on the accumulation of approximately 6.5 billion tons of metals, while annual world steel production in the year 2000 is estimated at approximately 2.5 billion tons, considerable importance is assumed by the conservation of metals possible in a scientifically substantiated production-consumption-production cycle [4]. Substantial scientific research activities are being conducted in this area. Meriting particular attention is research on recovery of nickel, tungsten, and molybdenum plus other valuable metals from scrap metal and complex-alloy steel and special alloy waste. Such research is being conducted in many industrially developed countries, especially in Japan, where valuable metals are already being recovered from waste from Japanese enterprises.

In this country the VNIIPIL [expansion unknown] Institute, jointly with the Institute of Metallurgy imeni A. A. Baykov of the USSR Academy of Sciences and the Gor'kiy Vtorchermet Association, is also conducting research on recovery of valuable metals from high-grade steel waste, and the enterprises of Vtorchermet have obtained furnace-charge steel ingots with a lower content of impurities than is obtained in foreign practice.

Recycling of metals should be adopted as a reliable foundation for conserving metals, while shortages in the metals balance should be made up with newly-mined mineral resources (with comprehensive utilization of the raw ore) -- this is the way to provide for continuous growth in the economy's metals requirements [3, 4].

There is no scientifically substantiated definition of the term "kompleksnoye ispol'zovaniye syr'ya" [comprehensive utilization of raw materials] in the scientific and technical literature. Most frequently qualitatively differing definitions are given to this term, especially by branch production facilities: increased recovery of valuable components, organization of by-product production of a new product from waste, expansion of the variety of products from the same quantity of raw materials, simple recovery of waste materials, etc. For example, although the nonferrous metallurgical industry extracts from raw materials more than 70 percent of metals and valuable elements [9], nevertheless raw materials are not utilized in a comprehensive manner, just as in the ferrous metallurgical industry which, possessing ores containing almost all nonferrous and rare metals in addition to iron, recovers for all practical purposes only vanadium and phosphorus [10]. The point here is not only sluggishness and unwillingness on the part of certain ministries, which unfortunately occurs, but also the absence of a clear-cut scientific strategy of efficient utilization of mineral ores, a strategy to which ministries and agencies would adhere not only by conviction but also by necessity.

The absence of clarity in the term comprehensive utilization of raw materials and unification of qualitatively diverse production-economic processes in it creates a confusion of the characteristic features of a subject in which economic and technological studies are being conducted, planning, evaluation of the effectiveness of comprehensive utilization, etc. The absence of a proper scientific foundation in this matter requires caution in making an objective evaluation of data pertaining to increasing, for example, the effectiveness of recovery of metals, since these are most frequently localized indicators (for one type of raw material, enterprise or subbranch), without comparison with socially essential outlays to obtain an equivalent quantity of recovered metal [11, 12].

The sector/branch approach in substantiating economic effectiveness also most frequently predominates in technical-economic reports and substantiations -- the principal documents prepared by economic departments of design institutes and utilized by higher agencies in making practical decisions. These official documents poorly take into account the achievements of basic and applied research by academic institutes, most frequently assessing them as "insufficient" for utilization in engineering design. And decades go by before promising industrial processes are utilized. For example, for several five-year periods now industry has not been utilizing project results produced by the Institute of Metallurgy imeni A. A. Baykov of the USSR Academy of Sciences and the Institute of Metallurgy of the UNTs [Ural Scientific Center] of the USSR Academy of Sciences, carried out jointly with a number of branch institutes and plants, in the area of comprehensive utilization of titanium and niobium raw materials, especially obtained from ample-supply nonbalance ores (projects of the Institute of Metallurgy imeni A. A. Baykov of the USSR Academy of Sciences, the Titanium Institute of the Chelyabinsk Affiliate of NIPROIMS [expansion unknown] of the Pigment LNPO [expansion unknown], the Zaporozh'ye and Bereznikovskiy Titanium-Magnesium combines, etc), while our country, which possesses reserves of titanium and niobium raw materials, is compelled to import raw materials from Norway, Australia, and Brazil [9].

Obviously when making practical decisions and drawing up five-year plans it is essential, alongside TEO [Technical-Economic Substantiations] and TED [Technical-Economic Reports] as scientific foundation, to utilize proposals proceeding from the comprehensive scientific and technical progress program elaborated by the USSR Academy of Sciences and USSR State Committee for Science and Technology, as well as scientific-technical reports of institutes of the USSR Academy of Sciences in the area of comprehensive utilization of the raw materials of various regions and associations of mineral deposits. Therefore research conducted by IMET [Institute of Metallurgy] imeni A. A. Baykov and IMET of the USSR Academy of Sciences UNTs and other academic institutes in the area of comprehensive utilization of raw materials must be strengthened and raised to the level of the demands of engineering solutions, while the scientific level of TEO and TED in the area of utilization of ore raw materials should be placed under the supervision of the Council for Comprehensive Utilization of Ore Raw Materials, the advisability of establishment of which under the auspices of the USSR Academy of Sciences was recognized as early as 1976 by the First All-Union Conference on Comprehensive Utilization of Ores and Concentrates. Such supervision will make it possible to ensure that comprehensive utilization of raw materials becomes a working strategy in the exploitation of mineral resources, will enhance the role of science in resolving these problems and will bring scientific research and development closer to solution of the most important problems in the area of development of production.

It is up to science to overcome the customary view prevailing among our managers that the Soviet Union is unusually wealthy in mineral resources and their confidence that geologists will always be able to find rich sources of mineral raw materials (our country contains approximately 50 percent of world iron reserves! [13]). In addition, extraordinary circumstances have very frequently forced us to refrain from comprehensive exploitation of mineral deposits and to choose accelerated exploitation of some one raw material [14]. Unfortunately this forced tactic has been transformed, on the soil of ministerial interests, from a necessity to a habit and, in view of the difficulties of counterbalancing ministerial isolation, has resulted in serious consequences, especially for the environment: mountains of spoilbanks and wastelands of tailing dumps, which contain associated components comparable in value to the basic raw materials utilized in ferrous and nonferrous metallurgy, the chemical industry and the building materials industry.

There is no single-mineral raw material in nature. The division of raw materials into ferrous and nonferrous metal ores is arbitrary. Iron ores of ancient and especially young platforms are major sources of nonferrous and rare metals. It follows from a general description of the nation's iron-ore balance that the balance partially covers the following: vanadium, germanium, and gold [15]. According to the structure of consumption (production) of iron ore, only vanadium is partially recovered together with the iron. The following are lost in ferrous metallurgy: copper and cobalt (Vysokogorskoye deposit, Urals; the total amount of losses has increased to 100 million rubles); copper, cobalt, lead, zinc, gold, sulfur, and rare-earth metals (Sokolovskoye and Sarbayskoye deposts; recovery of copper alone from these deposits can produce annually an additional output of 10 million rubles and 4.5 million tons of sulfuric acid); phosphorus, zirconium and raw materials for the electroceramics industry (the Kovdorskoye deposit on the Kola Peninsula; less than 60 percent of the value of components contained in each ton of ore is utilized), etc [16]. In nonferrous metallurgy [3, 4, 10, 17] slightly more than half of total valuable components are recovered from complex and copper ores (83 percent of copper, 43 percent of zinc, 30 percent of gold, and 40 percent of silver are recovered from Ural copper-zinc ores), while the following are totally lost: iron (1.5-2.0 million tons per year just in processing of copper concentrates), rare earths combined with non-ore minerals (complex ores of Kazakhstan), zinc and lead (Darasunskoye goldfield), gold and silver (Shakhtominskiy Molybdenum Combine); gold, silver, and rare earths (tin ores of the Solnechnoye deposit); sulfur (Noril'sk Combine, etc).

The chemical industry is not comprehensively utilizing the ores of the Khibinskiye apatite-nepheline deposits -- the principal source of phosphate for this country's production of mineral fertilizers [4, 14]. Phosphorus is recovered from the above ores and, to some extent (15-20 percent), fluorine, aluminum, sodium (soda products), potassium, gallium (less than half of the value structure is recovered from the raw material), but titanium, niobium, vanadium, iron, strontium, and rare earths are totally lost. A total of 20 million tons of aluminum, 2.7 million tons of titanium dioxide, 14 million tons of strontium oxide and sodium oxide went into tailings dumps just in the period 1971-1975. A total of 1.9 million tons of strontium oxide, 0.7 million tons of oxides of rare-earth metals, and 1.5 million tons of fluorine were lost in production processing at enterprises of Minkhimprom [Ministry of Chemical Industry]. Production of Khibinskiye ores has increased fivefold in the last 15 years, and totaled 41.7 million tons in 1977. Losses of the above-listed metals have been increasing proportionately to production.

The specific features of modern production are such that 90 percent of mined rock goes into tailings. Each year more than 2 billion cubic meters of various rock and concentration tailings, 100 million tons of metallurgical slag, 94 million tons of coal ash, almost 140 million tons of dust, etc are dumped. The spoilbanks of the Krivoy Rog Basin alone, for example, contain "reserves" of more than 300 million tons of ores with an iron content of up to 38-45 percent and approximately 500 million tons of oxidized quartzites [13]. The slags of some of Kazakhstan's mining enterprises have from 2 to 3 times the metal content as in some specially mined ores. However, since these reserves have been subjected to practically no study at all, they cannot be figured in with reserves [10].

Channels of irrevocable losses of raw materials remain open. At the same time more than 66 million tons of mineral and chemical substances in the form of fumes, dust and gases are ejected into the atmosphere by plants and factories, while 11 cubic kilometers of untreated effluent is being discharged into bodies of water. In 1975 the water consumption of the nation's economy comprised 6 percent of this country's river discharge, and it will comprise 12 percent in 1990. Of 37.6 cubic kilometers of polluted effluent, 74 percent is subjected to treatment, after which the "conditionally pure" water requires 40-50:1 dilution, which today can no longer be achieved on the majority of this country's rivers [3].

Also substantial are "hidden" losses of metals due to insufficient study of the material composition of ores and distribution of elements between minerals [18]. Metals which cannot be recovered by modern concentration means, so-called "screen" metals -- nickel, cobalt, titanium, vanadium, niobium, and others -- pass into metallic phase during metallurgical processing in the form of alloying elements, a portion of which is recovered (up to a certain limit in dust, sublimates and other intermediate products), while a portion remains in the metal in the form of unremoved microalloying elements, the quantitative and qualitative composition of which forms the "heredity" characteristic of metal from each deposit (Demidovskiye steels, which are not subject to corrosion; Magnitogorsk metal, containing nickel and cobalt; Nizhniy Tagil, microalloyed with nickel, platinum, titanium, and vanadium; Kerch' -- with vanadium and manganese; Krivoy Rog -- with germanium, chromium, niobium, titanium, etc). Some deposits from which high-grade metal could be obtained have been mined out (Magnitnaya Mountain), are close to being mined out (Vysokaya Mountain), or have been almost lost due to inefficient mining (copper-nickel deposits on the Kola Peninsula). Microalloyed metal is lost in the process of mass production of steels, in which, due to the multiple-stage nature of processing, process extraction of alloying elements, beginning from the ore, remains very low. In this case it would be advisable to return, on a new basis, to production of steel directly from ores, steel which was produced in the Urals by P. P. Anosov in the last century ("watered steels") [19]. The founder of Russian metallurgy, D. K. Chernov [20], dreamed of large-scale production of steel directly from ore. Projects of the Institute of Metallurgy of the USSR Academy of Sciences UNTs are continuing these fine traditions.

Nor can we ignore the ecological aspect of the problem. Hundreds of thousands of hectares of fertile land are occupied by spoilbanks and tailings dumps. Material ejected into the biosphere by the world's production enterprises today already exceeds the consequences of the Earth's considerable volcanic activity [3].

Thus the problem of rational and efficient utilization of raw material resources is a complex scientific and technical problem, solution of which requires change not only in technology but in scientific approach as well. In connection with this, study of the material composition of ore raw material, technological and scientific-economic evaluation of mineral deposits, and modern science of metals should be raised onto a higher scientific foundation, including within science of metals divisions covering research to develop alloys replacing short-supply materials, taking into account the abundance of metals in nature, as well as iron-based alloys with utilization of naturally alloyed metal products and with extensive employment of cermet methods (powder metallurgy).

Study of the abundance of elements in the earth's crust indicates that mankind should not be apprehensive about future raw material resources if industrial processes change in conformity with change in the composition of raw materials, and development of metal alloys will also be based on the abundance of metals in nature: metals of the first through fourth levels of abundance of elements, after Academician V. I. Vernadskiy (iron, aluminum, magnesium, and titanium) should comprise the basis of widely utilized alloys, while alloying agents (low-abundance metals) should be selected from the fourth through tenth levels of abundance of elements.

Thus rational utilization of ore resources presupposes first and foremost rational utilization of methods. A unity of development of science and technology in the age of research and development, with science advancing at a priority pace, will ensure the development of metals production for full satisfaction of the requirements of the national economy on the basis of solution of the problem of comprehensive utilization of ore raw materials. Sector/branch orientation in this process of development of production as a whole should everywhere withdraw to a secondary level, since it has already played its progressive role at the stage of creation of large-scale first-class production of metals in this country. We must agree that at the new stage of development of metallurgy, with the noted raw materials difficulties, both inevitable and hidden losses of metal impurities and valuable elements, which comprise an equal or larger portion of the value of an ore, become increasingly unwarranted. We cannot permit continuation of a situation where we allow in ferrous metals production almost the total loss of nonferrous and rare metals contained in iron ores and, on the contrary, total loss of iron in the production of nonferrous metals [3].

It obviously follows from the above that present industrial processes and the structure of production should undergo significant changes in the near future, including the creation of industrial complexes which combine in a single process cycle the production of metals, chemical, building and other materials essential for the nation's economy.

Further advance in metallurgical production is connected with the development of metallurgical science, one component part of which is comprehensive utilization of mineral raw materials, ensuring an abundance of metals and protection of the environment. "We should wage a struggle for raw materials proper," stated Academician A. Ye. Fersman. "We should understand and recognize those unique mineral raw materials on which we shall be building our industry.... We must flexibly adapt production proper to new types of raw materials, not the reverse, adapting our raw materials to old production processes.... Each commercial mineral can be evaluated only when it is examined in the entire complex.... We must learn to utilize the entire mineral-rock mass, industrial-processing all waste and discards, increasing the scale and interweaving the outputs of different shops" [21].

Evidently the problem of comprehensive utilization of ore raw materials should for practical purposes be resolved in three sequential stages: maximum utilization of the possibilities of the branch structure of present metals production for accomplishing tasks of by-product recovery of metals and other valuable by-products; construction of a new facility for processing ore raw material of complex composition, obtaining synthetic raw materials meeting the high demands of existing high-output industrial processes in metals production and, finally, establishment of regional industrial complexes for efficient utilization of the diversified range of raw materials of a number of ore bodies without creation of waste to be discharged into the environment, on the basis of nuclear power engineering. Departure from the strict industrial-branch orientation of our economy will apparently prove justified, since it has already played its determining role in the creation of a large-scale metallurgical industry, and the present task is to achieve qualitatively new development of technology, which should provide production not only of metals but also of other materials necessary to the economy.

Considerable scientific and technological know-how has been amassed in the area of comprehensive utilization of raw materials. Entire subbranches in nonferrous metallurgy are operating on the basis of efficient utilization of raw materials: titanium production and processing of nepheline concentrates, etc; in ferrous metallurgy: utilization of Kerch' iron ores (Azovstal'), Kachkanar titanomagnetites (Nizhniy Tagic Metallurgical Combine), etc. The efficiency of comprehensive utilization of raw materials is confirmed by the results of studies by the Tulachermet Scientific-Production Association, IMET imeni A. A. Baykov of the USSR Academy of Sciences, the Institute of Metallurgy of the USSR Academy of Sciences UNTs, and other institutes and scientific-production associations [5]. Their studies have shown the possibility of: achieving savings in short-supply iron ore by utilizing sintering-blastfurnace and steelmaking sludges, vanadium raw material, including utilization of ash residue from the combustion of high-sulfur residual fuel oil at this country's power generating plants; direct alloying of steel with metallized vanadium-containing pellets of Kachkanar concentrates, metallized concentrates of iron-chromium-nickel and complex ores; replacement of duplex pig iron processing in a converter shop to a single process; separation of vanadium and phosphorus by direct slag reduction with ferro-silicon, obtaining master alloys containing up to 12 percent vanadium and 25-30 percent silicon; production of niobium, barium, and cobalt master alloys from complex raw materials, as well as naturally alloyed iron powders.

Research conducted by IMET imeni A. A. Baykov has shown that nonferrous metallurgical enterprises may in the future become large suppliers of iron powders, and USSR Minkhimprom a large supplier of synthetic raw materials for producing nonferrous and rare metals. IMET of the USSR Academy of Sciences UNTs has worked out the fundamentals of a new and promising direction in the area of comprehensive utilization of sulfide polymetallic raw materials, obtaining ferrite-calcium slags which are new in nonferrous metallurgy. This process, alongside recovery of nonferrous and rare metals and sulfur, makes it possible to resolve the problem of extracting iron from complex ore by converting it to sulfur-clean fluxed raw material for ferrous metallurgy. Jointly with industrial enterprises and the All-Union Institute of Aluminum and Magnesium, the Ural Polytechnic Institute imeni S. M. Kirov, and IMET of the USSR Academy of Sciences UNTs, schemes have been proposed for the comprehensive processing of sludges and slag recovery, including ferrous metallurgical slags (slags department of the Ural Scientific Research Institute of Ferrous Metallurgy), with recovery of principal valuable components and utilization of residue in the cement industry as binding construction materials. The immediate task consists in commercial verification of these schemes, selection and adoption of an efficient arrangement. Accelerated solution of the problem of comprehensive utilization of ore raw materials will be promoted by establishment of experimental-industrial facilities for IMET imeni A. A. Baykov and IMET UNTs USSR Academy of Sciences. The experience of IMET imeni A. A. Baykov of the USSR Academy of Sciences and the Tulachermet Scientific-Production Association confirms the prospects of this area of development, and therefore one should note as a positive occurrence the instructions issued by USSR Minchermet to Uralchermet and Uralgipromez to draft proposals on this question.

It is high time to raise to a higher level the role of science in solving the problem of comprehensive utilization of raw materials, considering its principal content to be efficient utilization of natural resources in the interests of the nation's economy, as well as a conscientious appraisal of the economic and social consequences of forced and chance solutions in this area, so as not only to localize them in time but also to reduce their negative effect to the greatest possible extent. It is evidently essential to designate a lead institute in the USSR Academy of Sciences on this problem, possibly IMET imeni A. A. Baykov of the USSR Academy of Sciences.

It would be appropriate to establish under the auspices of the lead institute on this problem an Interagency Council for the Efficient Utilization of Ore Raw Materials, assigning it the job of evaluating the scientific substantiation of technical decisions in this area (TEO and TED), submitted to Gosplan, adoption of scientific and technical reports on regional problems of comprehensive utilization of raw materials, preparation of a Comprehensive Program of Scientific and Technological Advances in Metallurgy and, in connection with this, measures for their adoption by the commission on comprehensive utilization of commercial minerals under USSR Gosplan, as well as coordination of scientific research activities on this problem.

Solving the problem of comprehensive utilization of ore raw materials requires seeking new organizational forms of integrating science and production (comprehensive programs of basic and applied research, which are reflected in the pace of development of science and technological advances in the nation's economy). These new forms include 15 comprehensive programs of the Siberian Department of the USSR

Academy of Sciences, ranging from microelectronics to utilization of natural resources for agriculture, the experience of the Ukrainian SSR Academy of Sciences in establishing large scientific complexes based on leading academic institutes, complexes which include branch institutes, design offices, experimental production, and an experimental plant.

Comprehensive utilization of ores and concentrates is becoming a most important condition for the further development of metallurgy in general and in the Urals in particular. It will provide this region with large reserves of local raw materials, a high rate and level of development of the economy as a whole, as well as increased efficiency of societal production on the basis of accelerated exploitation and efficient utilization of raw material resources. One should bear in mind thereby that specific capital and labor outlays in the extractive industries are significantly greater than in the processing industries, and therefore savings in raw materials through processing, which also presupposes their comprehensive utilization, opens up the possibility of significantly improving production efficiency as a whole. A second factor evoking the necessity of efficient utilization of ore raw materials is connected with protection of the environment and elimination of discharges into the atmosphere. Comprehensive (efficient) utilization of raw materials predetermines the creation of waste-free industrial processes.

Future advance in metallurgical production is determined by the development of metallurgical science, one component part of which is elaboration of the scientific basis for comprehensive utilization of ore raw materials and waste-free industrial processes in the metallurgical industry. Following are the most important trends in development of metallurgy of complex ores: elaboration of the scientific principles and adoption of technologies of efficient (comprehensive) utilization of ore raw materials, energy, metal and other materials, including waste-free processes of obtaining semimanufactures; elaboration of the scientific principles of a system of indicators preventing production adoption of processes detrimental to the environment and an efficient structure of production and consumption of metals; development of biological methods of treatment with the aim of creating waste-free manufacturing cycles with a closed-cycle water supply system; total elimination of highly toxic elements from production operations; utilization of the heat generated by nuclear power stations and plasma heating in the metallurgical industry; development of geotechnologies (elaboration of the scientific and technological principles), including underground leaching, exploitation of seabed mineral deposits, underground scorification of deep-lying deposits (these methods, foreign scientists acknowledge, could become the foundation of the extractive industry by the beginning of the 21st century [22]); electrochemical reduction of metals in molten media; elaboration of the scientific principles of biometallurgy, as well as basic research connected with solving the problems of comprehensive utilization of ore raw materials (study of the intervalent reaction of transition metals in oxide, chalcogenide and salt systems and determination of its influence on the chemical and physicochemical properties of substances in various states of aggregation; study of the plasma state of ore matter and phenomena of directed electron transfer; reduction and oxidation processes for the purpose of concentration and separation of metals and metal compounds; study of exchange reactions and the influence of magnetic and ultrasonic phenomena on the properties of ore matter, as well as study of the technological and physicochemical properties of ores for the purpose of their metallurgical evaluation and elaboration of the scientific principles of technological evaluation of ore bodies on the basis of study of systematically selected samples for expanding technological mapping data on an ore body not only pertaining to dressability but also metallurgical properties [23].

Solving the most important problems of metallurgy in these areas will make it possible scientifically to organize production of a new type, where not a single gram of mined rock and mineral will be lost, where there will not be a single gram of discarded waste, where nothing will be discharged into the air or carried away by water [2]. Organization of such production proceeds from the nature of our socialist economy, for "our socialist system," stated Academician I. P. Bardin, the founder of modern metallurgical production,"makes it possible to a greater extent than anywhere else in the world to utilize fully all types of raw materials, semimanufactures and the waste products of one production process as usable materials for others" [23].

The principal task specified by the party as the most important condition for further growth and development of production during the coming five-year plans, is acceleration of scientific and technological advance in all branches and sectors of the economy. In the metallurgical industry this will be promoted by comprehensive utilization of raw materials, treated by waste-free processes, and efficient consumption of energy. A new mining and metallurgical industry is being created on this foundation, represented by closed-cycle regional energy-technological complexes, which will play a leading role in creation of the material foundation for the Communist society. "Only on the basis of accelerated growth and development of science and technology," stated Comrade L. I. Brezhnev at the 25th CPSU Congress, "can the ultimate tasks of the revolution of socialism -- the building of a Communist society -- be accomplished."

BIBLIOGRAPHY

1. Aleksandrov, A., "Forecasts and Hypotheses," NAUKA I TEKHNIKA, No 12, 1975.

2. Fersman, A. Ye., "Kompleksnoye ispol'zovaniye iskopayemogo syr'ya" [Comprehensive Utilization of Mineral Raw Materials], Leningrad, 1932, page 19.

3. Manokhin, A. I., "Address at the General Meeting of the USSR Academy of Sciences," VESTNIK AN SSSR, No 5, 1980, page 73.

4. Manokhin, A. I., and Reznichenko, V. A., "Metallurgy -- Science, Production and Future Development Prospects," IZVESTIYA AN SSSR, METALLY, No 3, 1980, page 3.

5. Vatolin, N. A.; Okunev, A. I.; and Leont'yev, L. I., "Problems of Comprehensive Processing of Raw Materials in Ferrous and Nonferrous Metallurgy in the Urals," KOMPLEKSNOYE ISPOL'ZOVANIYE SYR'YA, No 1, 1978, page 45.

6. Tun, J. K.; Arons, R. M.; and Clank, R. W., "Metals -- An Endangered Species," J. METALS, No 12, 1976, Vol 28, page 26.

7. Gerachimovich, G., "On the Approaches to Udokan," KOMSOMOL'SKAYA PRAVDA, 21 August 1980.

8. Kellogg, H. H., "The Role of Recycling in Conservation of Metals and Energy," J. METALS, No 12, 1976, Vol 28, page 29.

9. Lomako, P. F., "Nauka i tekhnicheskiy progress v tsvetnoy metallurgii" [Science and Technological Advance in Nonferrous Metallurgy], Moscow, Metallurgiya, 1972, page 136.

10. Laskorin, B., "Recovering the Riches From 'Low-Grade' Ores," PRAVDA, 15 Sept 1980, No 259 (22689).

11. Aleksin, V. P., and Tokareva, A. G., "Ekonomika kompleksnogo ispol'zovaniya v tsvetnoy metallurgii" [Economics of Comprehensive Utilization in Nonferrous Metallurgy], Moscow, Metallurgiya, 1976, page 224.

12. "Otsenka, prognozirovaniye, ratsional'noye ispol'zovaniye i okhrana mineral'nykh resursov" [Appraisal, Projection, Efficient Utilization, and Conservation of Mineral Resources], Novosibirsk, Nauka SO AN SSSR, 1980, page 144.

13. Egel', A. Ye., "Resursy chernykh, tsvetnykh i redkikh metallov i ikh promyshlennoye znacheniye" [Ferrous, Nonferrous and Rare Metals Resources and Their Industrial Significance], Gosgortekhizdat, 1962, page 200.

14. Laskorin, B., and Mel'nikov, N., "Nature's Bounty. Comprehensively Utilize Mineral Resources," SOTSIALISTICHESKAYA INDUSTRIYA, 28 August 1980.

15. Momdzhi, G. S., and Shmanenkov, I. V., "Sostoyaniye zhelezorudnoy bazy i zadachi kompleksnogo ispol'zovaniya zheleznykh rud" [State of the Iron Ore Base and Tasks of Comprehensive Utilization of Iron Ores], Dep. No 4455-76.

16. Sidorenko, A., and Mel'nikov, N., "Riches for All," IZV. SOVETOV DEPUTATOV TRUDYASHCHIKHSYA, 29 November 1971 (18429).

17. Malinova, R. D., and Glushkov, N. T., "Ekonomika tsvetnoy metallurgii SSSR" [Economics of USSR Nonferrous Metallurgy], Moscow, Metallurgiya, 1978.

18. Reznichenko, V. A., "Nauchno-tekhnicheskiy progress i kompleksnoye ispol'zovaniye rud i kontsentratov" [Scientific and Technological Advance and Comprehensive Utilization of Ores and Concentrates], Dep. No 1040-78.

19. Reznichenko, V. A., "The Academy of Sciences and Soviet Metallurgy," IVZ. AN SSSR, METALLY, No 3, 1974.

20. "Trudy D. K. Chernova" [The Writings of D. K. Chernov], Petrograd, published by the Russian Metallurgical Society, 1915.

21. Fersman, A. Ye., "Mineral Raw Materials of Leningradskaya Oblast and Their Future Prospects," PLANOVOYE KHOZYAYSTVO, No 5, 1931, page 6.

22. Laffitt, P., "Rudy -- yevropeyskaya problema" [Ores -- A European Problem], Moscow, Mir, 1969, page 182.

23. Bardin, I. P., "Razvitiye metallurgii v SSSR" [Development of Metallurgy in the USSR], Moscow, Nauka, 1966, page 14.

Moscow, Sverdlovsk Submitted 28 November 1980

COPYRIGHT: Izdatel'stvo "Nauka", "Izvestiya AN SSSR, Metally", 1981

3024
CSO: 1842/103

METALS INPUT OF SOCIETAL PRODUCTION

Moscow IZVESTIYA AKADEMII NAUK SSR: SERIYA EKONOMICHESKAYA in Russian No 3, May-Jun 81 pp 5-17

[Article by V. V. Astrakhantsev and V. D. Pavlenko: "Metals Intensiveness of Societal Production"]

> [Text] The authors examine and theoretically substantiate the difference between the terms "metalloyemkost' produktsii" [Metals Intensiveness/Metals Requirements/Metals Input of Production] and "metalloyemkost' obshchestvennogo proizvodstva" [Metals Input/Metals Intensiveness/Metals Requirements of Societal Production] at the level of the national economy. On the basis of a systems approach they present a grouping of factors which form the level of metals input. Reserve potential for reducing the metals requirements of societal production are shown.

The high level of development of the USSR national economy, its enormous scale, intensification of specialization and broadening of intersectorial linkages demand strengthening of the scientific substantiation of the development plans for all branches and sectors of the economy. Increased substantiation of ferrous metals production growth plans and other aspects of development of the ferrous metallurgical industry is promoted by correct determination of ferrous metallurgy production requirements. The magnitude of requirements in ferrous metals is determined by the scale of output of products employing ferrous metals and the level of metals requirements of these products.

The CPSU and Soviet Government devote considerable attention to matters pertaining to reducing materials and metals requirements. Specific guidelines pertaining to reducing metals requirements were drawn up at the 23d, 24th, and 25th CPSU congresses. The "Principal Directions of Economic and Social Development of the USSR for 1981-1985 and the Period up to 1990" also indicate the necessity of economically utilizing material resources and specify the target of reducing by at least 18-20 percent on the average the specific consumption of rolled ferrous metals in machine building and metalworking, as well as a 10-12 percent reduction in consumption of steel pipe. The 26th CPSU Congress strongly reemphasized the importance of reducing materials input as one way to improve the efficiency of societal production.

Considerable attention is devoted to the problem of reducing metals requirements in the Soviet scientific and technical literature. Up to the present time, however, there have been no generally accepted definitions of the concepts and indicators of metals requirements, which to a significant degree is due to the methodological complexity of the problem.

In this article the term metalloyemkost' produktsii shall be defined as the direct consumption (obshchaya metalloyemkost') or content (konstruktivnaya metalloyemkost') of ferrous metals in any unit of output. Production metals requirements can be expressed in physical or value units, depending on the purpose of the study and degree of aggregation of indices. At the level of the national economy, in the opinion of the majority of Soviet investigators, metals input should be calculated per unit of national income. Utilization of aggregate societal product or the gross output of individual branches/sectors for calculation produces distorted results in connection with the occurrence of a repeat count of material expenditures, which becomes increasingly greater with increasing deepening of specialization of societal production. Sometimes this indicator is presented as the metals input of societal production, evidently considering as sufficient foundation for this full encompassment of output volume on the scale of the entire national economy. In our opinion the term metalloyemkost' obshchestvennogo proizvodstva should have different economic content and differ from the term metalloyemkost' produktsii. This distinction is analogous to the distinction between the terms proizvoditel'nost' truda [labor productivity] and proizvoditel'nost' obshchestvennogo truda [societal labor productivity], which consists in the fact that the latter term encompasses expenditures not only of live but also of embodied labor. In conformity with this, metals input of societal production in its concrete annual cycle should be characterized by total expenditures of metal (including that portion of metal contained in the metals fund of the production branches/sectors of the national economy) for turning out products on a scale of the entire national economy. National income is adopted as quantity of annual output volume.

It is essential to take into account that portion of metal which was previously invested into the production edifice of the national economy, since an increase in metal contained in the fixed productive assets of ferrous metallurgy, machine building, metalworking and construction makes it possible to reduce metals requirements for current production, to improve the quality of metal products and reduce the level of metal waste, and boost labor productivity. One observes in ferrous metallurgy, for example, an increase in the specific metals intensiveness of fixed productive assets (the ratio of the total quantity of ferrous metals contained in fixed assets to annual output of finished rolled stock), which comprised 10.1 percent for a period of 12 years between the last revaluations [1], including 29.7 percent for the aggregate of specialized rolling-mill equipment which exerts decisive influence on the rolled stock quality level and product mix [2]. In machine building and metalworking the average annual metals fund growth rate was 7.1 percent for that same period, while average annual growth rate of consumed metal was 5.6 percent, that is, the former figure exceeded the latter by 30 percent. This is due to the greatly increasing complexity of machine building products and their improved technological level, which is imposing tougher demands on manufacturing process, process equipment, and raw materials. Thus a decrease in metals requirements for current production is due to an increase in quantity of metals in the fixed productive assets of the metallurgical industry, machine building and metalworking, while failure to take into account that portion of metal contained in these assets, when determining the level of metals input of societal production, leads to erroneous results and distortion of the actual change trends.

At the same time the metals intensiveness of societal production is formed in the process of annual production of aggregate societal product, which includes, as we know, the value of consumed means of production and newly created value; as a consequence of this, when calculating the level of metals intensiveness of societal production one should take into account all metal utilized in the current annual production cycle. Precisely this definition of the metals intensiveness/input of societal production ensures a methodological unity in studying reproduction of societal product on the basis of value and in physical terms.

In determining the level of metals input of societal production it is very important to select a methodologically correct initial position for figuring expenditures of metals. One should bear in mind that the historical experience of industrialization of the world's developed nations attests to an intensification of division of societal production and thus an increase in output of intermediate product and increasing complexity of intersectorial linkages. Therefore the necessity of studying the patterns of reproduction of intermediate product is obvious.

One of the elements of intermediate product is ferrous metals -- products of the ferrous metallurgical industry -- obtained as a result of utilization of metal-containing ores newly brought into economic circulation, other mineral resources, and secondary ferrous metals. Ferrous metals also represent a raw material for the metal consuming branches and sectors of the economy. Such a distinction in the role of ferrous metals in the process of their circulation dictates the necessity and expediency of beginning our calculation of the metals input of societal production from the moment of consumption of finished product of ferrous metallurgy and the metallurgical shops of the machine building industry, that is, finished rolled stock, steel pipe, products obtained from further processing, steel and iron castings. This approach will increase the validity of plan decisions on further increasing production of ferrous metals with the maximum possible reduction of metals input in the production of the metals consuming branches/sectors.

One cannot deny the importance of reducing the materials input into ferrous metallurgical production, which exerts a positive influence on improving the internal structure of this branch and strengthening its economic position.

In calculating the metals input of societal production, as we define this category, additional difficulties arise both in determining the quantity of metal contained in fixed productive assets and in settling the question of what portion of this metal should be included in current production outlays. This is due, in the first place, to a lack of any statistics on the metals fund of this branch[1] and, secondly, the methodological complexity of determination of this portion of metal.

The method of approximate determination of the consumed portion of means of labor in calculations of the materials input into societal production by means of figuring as this portion the total depreciation allowance contributions made during the year is unsatisfactory for the following reasons.

1. Standard service life figures on fixed productive assets do not correspond to actual figures, and consequently depreciation allowance contributions do not reflect the actual level of physical depreciation. Calculations indicate, for example, that the standard service life of fixed productive assets in industry is currently running 22-23 years, while the actual figure is 34-35 years.[2]

2. The depreciation fund reflects expenditures for full replacement and only a portion of expenditures for partial replacement of fixed assets by means of major repairs and overhauls. Expenditures on minor repairs are not included in the depreciation fund but are a component of current production expenditures.

3. In the course of the annual production cycle a portion of fixed assets undergoes repairs, which reduces the degree of their physical wear and tear and increases their residual value.

The erroneousness of employing this method in calculations of metals input into societal production is increasing, which is connected with differences in the duration of circulation of fixed productive assets in value and physical terms in general, and circulation of various structural materials within fixed assets in particular. For example, with an average service life of 20-22 years for metal-containing fixed assets, the service life of the metal in these fixed assets averages 13-14 years [5].

More precisely, in our opinion determination of the level of metals input in societal production is possible if one takes into account, as a portion of the metal contained in utilized fixed assets and consumed in the annual production cycle, that quantity of metal in retired fixed assets and consumed repair metal (both quantities should be recalculated and converted to original metal). Precisely this indicator corresponds to actual circulation of metal as a component of fixed productive assets. Figures from the annual ferrous metals scrap balances can serve as the statistical basis for such a calculation. Calculation of that portion of the metals fund which should be included in metals expenditures in the current annual production cycle is possible also by means of dividing the total magnitude of the metals fund of the branches of material production by the service life of metal as part of the fixed assets of these branches.

The metals input in societal production of the USSR, calculated in conformity with the above-described approach, declined in the period 1960-1975 by 62,500 tons per billion rubles of national income, or by 11.3 percent. This decline in the level of metals input occurred as a result of a decrease in current consumption of metals output amounting to 77,000 tons per billion rubles (19 percent) and an increase in the level of expenditures of metal invested in the nation's production edifice by 14,500 tons per billion rubles (9.8 percent). Even at the present time, however, the metals input in USSR societal production exceeds the counterpart U.S. figure by 40 percent.[3] This figure merely confirms the fact of greater expenditures of metal in the societal production of the USSR. But it cannot give a concrete picture of the magnitude of realistic reserve potential for reducing metals input and serves only as a point of departure for analysis of the factors which determine this difference.

There are a great many factors which affect the metals input of societal production. In addition, the versatility of utilization of ferrous metals as the material foundation of the implements of labor, means of transportation, and a preponderant portion of production and nonproduction structures as well as consumer durables, together with the phenomenon of metal circulation, dictates the dependence of volume of metals consumption on the level of development of all branches and sectors of the economy without exception.

Analysis of the great diversity of factors which determine the difference between the USSR and United States in level of metals input in societal production made it possible to specify five major groups of factors.

General economic factors characterize the state of a country's economy, the structural materials market, and the production edifice of the entire aggregate of investment branches/sectors. They include the following: rate of economic growth and branch/sector structure of national income, structure of structural materials and, in particular, metal products, and structure of the metalworking equipment inventory.

An elevated rate of economic growth, all other conditions being equal, presupposes, in the first place, channeling of a relatively larger percentage share of national income into accumulation, and secondly, an increase in the gap between the rate of growth of production of means of production (in particular, means of production for producing means of production) and production of means of consumption. This leads to a change in the branch/sector structure of national income toward an increase in the percentage share of the metals-intensive branches/sectors, which increases the overall level of metals input. The influence of this factor is quite substantial, since the level of the USSR in relation to the United States in total production in machine building, metalworking, and construction -- the only real metal consumers -- is 85-87 percent, and 67 percent of national income [7]. The dynamics of the branch/sector structure are also reflected on the level of the metals input of societal production, since the rate of growth of machine building and metalworking on the one hand and the construction industry on the other differently affect requirements in ferrous metallurgical products. This is attested by the coefficients of flexibility of production of finished metal products relative to change in the gross output of these branches calculated with employment of economic modeling methods (see table) [8].

Coefficients of Flexibility of Production of Final Metal Product in Relation to Output of Construction Industry (α_c) and Machine Building (α_m), 1960-1976

Metal Products	α_c	α_m	α_c/α_m
Steel	0.35	0.18	1.94
Pipe and tube	0.46	0.08	5.75
Finished rolled stock -- total	0.42	0.25	1.68
of that			
sheet	-* (*--see	0.24	-
merchant shapes	0.63 next	0.21	3.00
Ferrous metal castings	- page)	0.06	-
of that			
steel	-	0.11	-
iron	-	0.04	-
Industrial metal products	0.47	0.05	9.40

(* applies to table on preceding page) * The dashes denote that a coefficient of flexibility was not determined for the given item, in view of the specific features of the utilized economic-statistical model.

As is evident from the table, the relative influence of each percentage point of construction output growth on requirements in metal products is greater than the corresponding influence of machine building and metalworking. But in connection with the fact that the actual production growth rate of the latter was 250 percent greater in the specified period than in the construction industry,[4] machine building and metalworking are dominant in absolute influence on requirements in steel and finished rolled stock.

The structure of structural materials also plays a very important role in forming the level of metals input of societal production. Selection of one of the interchangeable materials in the concrete sphere of their utilization, with the technical equivalence of these materials, depends on their economic indices. The relatively higher percentage share of ferrous metals in the USSR (93 percent as compared with 85 percent in the United States) in the total volume of consumption of structural materials is due to the fact that the correlation of prices on these materials promotes consumption of ferrous metals rather than their substitutes to a greater degree than in the United States.

Another reserve potential for reducing the metals input of societal production is achievement of a more efficient structure of production and consumption of metal products proper (rolled stock, steel and iron castings). Consumption of items cast of iron and steel, which increase the metals requirements of industrial production, is still relatively high in the USSR. The present mix of products of ferrous metals is determined to a large degree by the structure of the equipment inventory of the primary processing facilities of the machine building and metalworking industry. Metal-cutting machine tools for machining merchant shapes and castings predominate in Soviet industry's metalworking equipment inventory, while the press forging equipment inventory is relatively small. A 1 percent increase in the percentage share of press forging and welding equipment decreases production metals input by approaximately 0.6 percent, while a like increase in the average age of the equipment inventory causes a metals input growth of 1.7 percent [11]. The relative insufficiency of press forging equipment is one of the reasons for a lower percentage share of economical sheet metal (41.8 percent) in finished rolled stock in the USSR [7, page 173] in comparison with the United States (63.0-65.0 percent) [12]. Formation of a progressive structure of the metalworking equipment inventory is a most important intersectorial problem of the national economy.

Factors operating at the stage of formation of the product mix structure of metals production and its utilization by consuming branches comprise a special set. In connection with localization of the operation of these factors largely in any one branch, they can be arbitrarily subdivided into metallurgical, machine building, and construction factors.

Metallurgical factors in formation of the level of metals input of societal production, in conformity with the point of departure adopted by us for our calculations, include the difference in product mix structure of metals output,[5] which determines the level of formation of waste metal in the economy. An increase in the metals utilization factor has been and remains an undisputed reserve potential for reducing overall metals requirements. As we know, the level of metal waste in the metal consuming branches/sectors depends on conformity between the geometric shapes and dimensions of the initial workpieces and the finished parts and product items obtained from them. Achievement of such a conformity is possible by expanding the type-size product mix of finished rolled stock and by reducing machining allowances. In this regard the USSR lags somewhat behind the developed capitalist countries. Rolled sheet produced in the USSR, for example, as a consequence of its inefficient structure (hot-rolled sheet and cold-rolled plate), averages approximately twice as thick as counterpart U.S. products. An insufficient number of different sizes in the Soviet product mix of simple sectional shapes is due in many cases to a lack of incentive for plants to turn out a higher-quality product. This is in part the reason for the relatively large amount of waste metal in metal consumption in machine building and metalworking in the USSR (22 percent) in comparison with the United States and the developed European capitalist countries (15.6 percent) [13]. We should note that change in the metal utilization factor both in the USSR and abroad is taking place extremely slowly, and has not exceeded 1-2 percent in the last 15-20 years.

The basic problems of the economics of improving the quality of metal products and enlarging the product mix are due to an objective cause -- the spatial distribution of expenditures channeled toward achieving this goal and the effect obtained as a consequence of this. As a rule improvement of product quality leads to a decrease in expenditures by the customer and the economy as a whole and to increased costs at metallurgical enterprises; in other words, the customers enjoy almost all the advantages (technical and economic) from the employment of higher-quality metal products, while the manufacturers are not fully compensated for their expenditures.

For example, additional capital spending and increase in the price of higher-quality metal in comparison with the run-of-the-mill metal product are as follows, in rubles per ton: 40 and 21 respectively for heat-treatment hardened rails at the Nizhniy Tagil Metallurgical Combine; 35 and 11 for 10-11 mm thick heat-treatment hardened plate; 70 and 30 for 0.7-0.8 mm cold-rolled sheet; 100 and 35 for cold-drawn steel sections; 70 and 7 for bent rolled sections [14]. Improvement in the system of prices, which at the present time do not fully take into account socially necessary expenditures of labor for the production of ferrous metals, will make it possible to eliminate as a result of revision of wholesale prices, after the new price lists become effective, some of the obstacles which are hindering improvement in the quality of metal products.

More reasonable satisfaction of requirements in higher-quality metal products, in addition to the problem of prices, is being impeded by problems in the system of planning economic indices and product mix loading of ferrous metallurgical enterprises. At the present time this work is being conducted in parallel by two economic management agencies -- USSR Minchermet [Ministry of Ferrous Metallurgy], and Soyuzglavmetall of USSR Gossnab. The economic indicators which can be obtained in the manufacture of metal products according to the specified product list drawn up by Soyuzglavmetall are at variance with the economic indices included in the ratified plan drawn up by USSR Minchermet on the basis of consolidated calculations.

Elaboration and extensive adoption into planning practices of scientifically substantiated plan-specified standards, which make it possible to coordinate changes in volume and qualitative production indices, is one way to overcome this conflict. In spite of the difficulties indicated above, improvement in quality and expansion of the product mix in ferrous metallurgy in recent years has accounted for 40-45 percent of the metal savings obtained in the machine building industry [11, page 57].

Machine building factors are a third major group of factors in forming the level of metals input of societal production. Of great importance among these factors is the branch structure of machine building, since consumption of metal per million rubles gross output in this branch ranges from 76 tons in instrument engineering to 945.6 tons in tractor and agricultural machine building, that is, a more than 12-fold spread [15]. An increase in the percentage share of instrument engineering in machine building output not only leads to a decrease in its specific metals requirements but also makes it possible more extensively to furnish all branches and sectors of the nation's economy with means of automation, which ensures growth in productivity of live labor and increased effectiveness of societal production. In the United States capital spending on means of automation increased from 7.1 to 43.4 billion dollars from 1963 to 1978, and their percentage share of total expenditures on machinery and equipment increased from 24.0 to 33.5 percent [16].

The internal branch category and type-size structure of manufactured machinery adversely affects the level of metals input of societal production in the USSR. In particular, the percentage share of the greater metals-requiring trucks and buses is relatively high in the total volume of automotive industry output, while in the tractor industry there is a high percentage share of caterpillar tractors, the manufacture of which requires the consumption of almost 2.2 times as much ferrous metals as is required in the manufacture of wheeled tractors. These differences, however, are due to the objective conditions of development of the Soviet economy. The reason for the former is the opposing nature of concepts of development of the transport system, due to the socioeconomic conditions of economic management of the USSR and the United States. Public passenger transportation is the emphasis in development in the USSR, characterized by the greatest economy, while personal transportation is predominant in the United States. The reason for the second difference is the fact that climatic conditions are different, in particular average annual rainfall. In the USSR it is necessary to employ caterpillar tractors for better moisture retention, as crawler-type tractors exert lower pressure per square inch on the soil being tilled (0.41 kg/m^2 as compared with 0.8 kg/m^2 with wheeled tractors). For this reason the percentage share of caterpillar tractors in the USSR is more than 45 percent of total production, while the figure is only 10-13 percent in the United States [9, page 229; 31].

There is considerable reserve potential for reducing metal consumption in the construction factors involved in forming the level of metals input of societal production. Considerable influence on the relatively large volume of consumption of ferrous metals (and other construction materials) in the USSR is exerted by the harsh climatic conditions, in which it is necessary to erect industrial, civil and housing capital structures which have greater requirements in building materials and metal. In the technological structure of capital spending and the category structure of fixed assets in the USSR, this is expressed in an increase in the percentage share of passive elements in fixed assets in the USSR. Change in the territorial structure of capital spending also operates in this direction, since a substantial portion of capital spending occurs in the northeastern part of this country, in conditions of an extremely harsh climate. In spite of the operation of these factors, however, current metal expenditures in construction in the USSR per unit of capital spending in 1979 were 16.4 percent below the 1960 level.

The next group of factors affecting the level of metals input of societal production involves utilization of the fixed productive assets of the USSR. Designation of these factors as a separate group, in spite of their general economic character, is due to a different role of ferrous metals, which function here as a substance of fixed productive assets, not as an object of labor.

The scientific literature has pointed to the link between the materials input in production and the output-capital ratio. Investigators have examined the influence of a decline in the materials input in production on increase in yield on capital. It was noted, in the first place, that a decrease in the materials input in production makes it possible to obtain more output from the same quantity of material resources per unit of time, which ensures, with fixed productive assets unchanged, an increase in yield on capital and, in the second place, utilization of less materials-requirements and consequently less expensive equipment in turning out the same volume of production leads to an increase in yield on capital [17, 18]. We consider it essential and particularly important, with the enormous scale of accumulation of fixed assets, to direct attention to an inverse linkage: the influence of output-capital ratio on materials and metals input.

Obviously the lower the level of utilization of operating fixed productive assets, the greater should be the magnitude of capital investment requisite for maintaining a specified rate of economic growth. A large magnitude of capital spending also requires large consumption of construction materials as well as a large quantity of machinery, equipment and means of transportation, which are almost entirely manufactured of ferrous metals. This also leads to an increase in metals requirements. In addition, the predominant channeling of resources into new construction, which is inevitable in this situation, does not permit prompt and timely replacement of physically worn out and obsolete means of labor, which causes a slowing of the rate of increase of efficiency of societal production, including from decreased metals input.

Magnitude of generated national income per unit of metals fund of this sector of the economy can serve as a tentative indicator of effectiveness of utilization of metal invested in the sphere of material production. It declined from 610.5 to 495.4 rubles per ton or by 18.9 percent from 1960 through 1975, with national income estimated in current prices, and by 15 percent with the estimate in comparable prices.[6] This is due partly to a decline in the level of utilization of production equipment. For example, figures from simultaneous 24-hour observations of utilization of production equipment at enterprises of the machine building ministries indicated that in 1975 the shift index was 78 percent for metal-cutting machine tools, while for press forging equipment it was 82.8 percent of the 1960 level.[7] The relatively low average level of extensive equipment loading is determined by the high percentage share of metalworking equipment utilized outside the machine building and metalworking industry, where it is utilized much less efficiently. This demonstrates the necessity, in order to increase the extensive loading of metalworking equipment, of its correct distribution, in the first place, between basic and auxiliary production and, secondly, between the machine building and non-machinebuilding branches.

One of the most important factors influencing the level of metals input in fixed productive assets is conformity between the technical parameters of the various elements of fixed assets and the needs of production and the degree of intensive loading of machinery and equipment determined by it. Time worked by a unit of electric motor capacity can serve as an integral indicator of equipment work in industry, characterizing the degree of loading (extensive and intensive). The magnitude of this indicator in the USSR went for more than 25 years without showing any clearly-marked trend, but it increased during the years preceding and following equipment and fixed assets censuses and revaluations, which is evident from the following figures:[8]

Years	Hours Worked, Unit of Electric Motor Output	Years	Hours Worked, Unit of Electric Motor Output
1950	1481	1970	1467
1955	1518	1971	1526
1960	1688	1972	1531
1961	1694	1973	1519
1962	1693	1974	1419
1966	1510	1977	1474

This comprises 65-80 percent of the work time fund with single-shift operations. Ya. B. Kvasha's calculations show that the time worked in industry by a unit of electric motor output can be increased to 3000 hours. This is also indicated by the experience of other countries. In particular, in the United States the analogous indicator (for a comparable group of industries) was 2745 hours [24, page 138]. In our opinion the reason for the relatively low level of this indicator in the USSR is the inefficient type-size structure of the equipment inventory and the high percentage share of manufacture of large, high-power equipment.

Precisely for this reason a study of the figures of five Moscow enterprises revealed a large gap between the performance specifications of 1K62 lathes and their actual utilization; the fact is that more than 80 percent of parts had a diameter of 100 mm or less, with a maximum allowable diameter of 400 mm, 86.3 percent were 500 mm in length or less with a maximum possible length of 1000 mm, and electric motor power was utilized at 20-30 percent [27]. We know that increasing lathe swing and distance between centers causes lathe dimensions and weight to run ahead of growth in requirements. A study of milling machines and drill presses produced similar results.

There exist a number of additional examples of significant underutilization of the technical capabilities of powerful and, most important, mass-utilization equipment. The present situation demands thorough substantiation of the necessity of boosting the average unit output and productivity of equipment (especially for branches with a discrete nature of production). The effectiveness of increasing these parameters should be determined proceeding from realistic possibilities of their full utilization. An endeavor to reduce specific metals input by means of unwarranted growth in equipment productivity, when allegedly for the purpose of achieving savings in ferrous metals powerful equipment is manufactured the parameters of which are utilized at 25-30 percent, results in a low level of return on investment, overexpenditure of metal, and substantial economic losses. Enormous reserve potential for reducing the metals input of societal production is to be found precisely in optimization of the type-size structure of manufacture of the principal types of machinery, equipment and transport vehicles.

Many authors assign to a special group those factors which are connected with foreign trade [28, 29]. The level of materials input in production is made dependent only on the percentage share of products of the extractive industries, metallurgy and high materials input types of machine building products in the exports of the target country, and on the percentage share of relatively inexpensive raw materials, structural and other materials in import. The influence of foreign-trade activity on the level of materials intensiveness (metals input), however, is not limited to this alone. The direct influence of foreign trade on the denominator of this indicator is connected with the fact that a portion of a country's national income is generated by foreign trade, as one of the sectors of material production, a portion which can fluctuate significantly, depending on the operating conditions of this sector. The principal influence of foreign trade on the level of metals input of societal production is exerted not directly but indirectly, by affecting the branch/sector structure of the national economy and affecting improvement in the operating efficiency of the branches and sectors in which higher-quality or less expensive imported raw materials and fuel, advanced equipment and technology are employed. Both are reflected, in conformity with our adopted classification, in the groups of general economic factors and factors of utilization of fixed productive assets.

We should note that essentially there is possible a situation where an increase in the metals input of societal production through exporting products of the metals-intensive industries is counterbalanced or more than balanced by a decrease in metals input by importing advanced equipment and technology which promotes improved efficiency of societal production. On the whole the question of the influence of foreign trade on the level of metals input (materials input) has not been comprehensively and thoroughly discussed in the economics literature, but it is extremely important for purposeful management of this process.

We must also point to factors of decrease in metals input of societal production connected with improvement of the economic management mechanism and strengthening of its effect on improving the efficiency of societal production of the USSR. These include first and foremost improvement in organization and management of production, improvement in the system of supply, increased comprehensiveness of bringing fixed productive assets on-stream and a general acceleration of this process, and optimization of distribution of metal products between manufacture of equipment proper on the one hand and manufacture of replacement equipment and replacement parts on the other.

Resolution of the latter problem is of particularly critical importance, since in recent years there has been observed in the USSR a steady increase in the quantity of scrap iron and steel retired from service as a consequence of major overhauls and minor repairs, and the quantity of metal channeled into the manufacture of spare parts, relative to the current consumption of all types of ferrous metals in the nation's economy:

	1960	1965	1970	1979
Collection of scrap generated by major overhauls and minor repairs	9.7	9.9	10.4	10.8
Consumption of metal for manufacture of replacement parts	21.5	22.0	23.0	23.9

Note: Calculated proceeding from the amount of shortfall in collecting scrap generated by major overhauls and minor repairs -- 24-28 percent; fixed assets losses during service life from wear and corrosion -- 10 percent; and metal utilization factor in manufacture of spare parts -- 0.65-0.68. See [5].

At the same time, according to present estimates, in the United States only 5-6 percent of current metal expenditures for manufacture of machine building products is being consumed for the manufacture of spare parts [3]. This is due to the shorter average service life of fixed capital in the United States in comparison with fixed productive assets in the USSR, as well as the relatively small number of parts and assemblies replaced during machinery overhauls in the United States, which is due to the extensive employment of nonferrous metals for the fabrication of critical parts and their high degree of strength.

A study conducted by the Dnepropetrovsk Metallurgical Institute revealed the inefficiency of repairs and overhauls on rolling-mill equipment which had been serving for 20 years or more, in view of the significant increase in expenditures on replacement of parts and assemblies and large expenditure of metal on them, which is not economically justified by extending the service life of the repaired equipment [30]. Rapid growth of expenditures on overhauls and repairs with an increase in service life is also characteristic of other types of machinery and equipment. Thus it is possible to optimize the correlation between manufacture of equipment and spare parts for it only with establishment of economically advisable service lives of fixed productive assets. The result of solving this problem will be a sharp rise in the level of utilization of fixed productive assets, reduction in expenditure of metal for the manufacture of replacement parts, and an overall decline in the metals input of societal production.

Transition to planning production volumes, labor productivity growth and forming of material incentive funds on the basis of a standard-net product indicator, adopted into practical socialist economic management by the CPSU Central Committee USSR Council of Ministers Decree of 12 July 1979 entitled "On Improving Planning and Strengthening the Effect of the Economic Mechanism on Improving Production Efficiency and Work Quality," constitutes a cardinal turning point toward materials-conserving development of the metals-consuming branches/sectors. Utilization of this indicator eliminates the possibility of improving the economic indices of enterprises and production associations by turning out materials-intensive product. All this, together with measures to improve organization and planning of construction, to improve the system of prices on industrial products, and to enhance the role of meeting purchase orders, will make it possible consistently to reduce the metals input of societal production.

Thus metals intensiveness of societal production is a combined indicator of utilization of ferrous metals in the economy. Analysis of its level touches upon a broad range of branch/sector and national economy problems and by its nature must be of a combined character. Differences between countries in level of metals input of societal production cannot be explained correctly to any degree with a limited set of factors which operate only in ferrous metallurgy and directly in the metals-consuming branches/sectors. They are determined by structure and efficiency of societal production as a whole.

The restricted nature of a journal article makes it impossible to discuss all aspects of the problem of metals input of societal production. In particular, we have not discussed representativeness of indicators of metals input and their reducibility from lower to higher hierarchic levels, as well as questions dealing with the comparability of these indicators between different countries, which are highly complex as a consequence of differences in the structures of aggregate societal product, methodology and principles of pricing, levels of labor productivity, and quality of metal. It is essential to resolve these matters in order to achieve precise quantitative determination of reserve potential and to draft practical recommendations for increasing the economic effectiveness of societal production in the USSR on the basis of reducing its metals input.

BIBLIOGRAPHY

1. Zusman, L. L.; Astrakhantsev, V. V.; and Kireyev, Yu. V., "Metals Input in Fixed Productive Assets of Ferrous Metallurgy," STAL', 1976, page 1051.

2. Zusman, L. L., and Astrakhantsev, V. V., "Specific Metals Intensiveness of Specialized Rolling-Mill Equipment in the USSR," in the volume "Ekonomika chernoy metallurgii" [The Economics of Ferrous Metallurgy], Moscow, Metallurgiya, No 7, 1978, page 32.

3. Zusman, L. L., "Metallicheskiy fond narodnogo khozyaystva SSSR" [Metals Fund of the USSR National Economy], Moscow, Metallurgiya, 1975, page 274.

4. "Narodnoye khozyaystvo SSSR v 1977 godu" [National Economy of the USSR in 1977], Moscow, Statistika, 1978, pp 40, 558.

5. Zusman, L. L., "Krugooborot metalla v narodnom khozyaystve SSSR" [Circulation of Metal in the National Economy of the USSR], Moscow, Metallurgiya, 1978, page 161.

6. Nechayev, A. A., "Analysis of Structural Changes and Interrelationships of Development of the Branches of Industry Between Countries," Izv. AN SSSR, ser. ekon., No 1, 1979, page 42.

7. "Narodnoye khozyaystvo SSR v 1979 godu" [USSR National Economy in 1979], Moscow, Statistika, 1980, page 67.

8. Pavlenko, V. D., "Modelirovaniye dinamiki produktsii otrasli (na primare chernoy metallurgii SSSR)" [Modeling the Production Dynamics of an Industrial Branch (On the Example of USSR Ferrous Metallurgy)], author's abstract of dissertation for the degree of Candidate of Economic Sciences, Moscow, MGU, 1979, page 19.

9. "Narodnoye khozyaystvo SSSR za 60 let. Yubileynyy stat. yezhegodnik" [60 Years of the USSR National Economy. Jubilee Statistical Yearbook], Moscow, Statistika, 1977, pp 79, 174, 433.

10. "Narodnoye khozyaystvo v 1965 godu" [The National Economy in 1965], Moscow, Statistika, 1966, pp 126, 529.

11. Fal'tsman, V. K., and Kristal'nyy, S. B., "Statistical Analysis of the Possibilities of Reducing Metals Input in Machine-Building Production. Izvestiya AN SSSR, ser. ekon., 1979, no. 6, pp 59-60.

12. Ferrous Metallurgy in Capitalistic and Developing Countries. Collected statistical materials. Moscow, Chermetinformatsiya, 1978, part 2, p 25.

13. Ferrous metal scrap , its significance and effects on the further development of ferrous metallurgy. EEK OON. ECE/Steel-24, 1978, p 2.

14. Bobylev, G. K., Cheplanov, V. I., Sorokina, N. K. Increasing the Earning Capacity in Ferrous Metallurgical Production. Moscow, Metallurgiya, 1976, p 135.

15. Zusman, L. L., Increasing the Effectiveness in the Utilization of Ferrous Metals in the Economy. Review information, series 23, no. 1. Moscow, Chermetinformatsiya, 1978, p 18.

16. Developing Capitalistic Countries (Social-Economic Handbook) Under the editorship of Mileykovskiy, A. G., Moscow, Politizdat, 1979, p 99.

17. Polyak, A. M., Intensification of Production and the Problem of Reducing Materials Input. Moscow, Ekonomika, 1973, p 10.

18. Pashko, I. G., Problems in Reducing Metals Input, Moscow, Metallurgiya, 1977, p 33.

19. The USSR Economy in 1968. Moscow, Statistika, 1969, p 569.

20. Demb, B. I., A Comparative Analysis of the Branch Structure of the Metallic Fund of the USSR and the United States. Express information, series 23, no. 2. Moscow, Chermetinformatsiya, 1977. p 12.

21. Palterovich, D. M., Planning Requirements in Equipment. Moscow, Ekonomika, 1972, p 159.

22. The Utilization of Productive Equipment at Machine-Building Enterprises of Ministries. Vestnik statistiki, 1976, no. 4, pp 93-94.

23. The Industry of the USSR. Collection of articles. Moscow, Statistika, 1964, p 80.

24. Kvasha, Ya. B., Reserve Power. Moscow, Nauka, 1971, p 137.

25. Capital Inputs in General Production. Minsk, Nauka i tekhnika, 1977, p 125.

26. Palterovich, D. M., Ways of Increasing Effectiveness in the Use of Equipment. Planovoye khozyaystvo, 1979, no. 10, p 110.

27. L'vov, D. S., Fundamentals of the Eoonomic Designing of Machines. Moscow, Ekonomika, 1966, pp 25-28.

28. Kudrov, V. M., Concerning Materials Input in General Production in the USSR and the United States. Me i Mo, 1965, no. 5, p 79.

29. Vintrova, R., Materials Input in the Production in CEMA Countries. Voprosy ekonomiki, 1979, no. 5, p 93.

30. Ben', T. G., Ryabchiy, M. Ye., Puzyr'kova-Uvarova, L. F., The Utilization of Basic Production Funds and Design Power in Ferrous Metallurgy. Kiev, Tekhnika, 1974, p 72.

31. Statistical Abstract of the United States 1977. Washington, 1977, p 824.

FOOTNOTES

1. Work on computing the metals fund in the USSR is performed sporadically, in conformity with equipment censuses and revaluations of fixed assets. See [3].

2. Standard service life is determined by dividing the average annual value of fixed productive assets by total annual depreciation allowance contributions for renovation. The actual figure is determined with the O. Lange formula:

$$B= \frac{\Phi}{C(1+T\cdot C)},$$

where B -- retirement of fixed assets; Φ -- current value of fixed assets; C -- service life of fixed assets; T -- average annual fixed assets growth rate. Calculated after [4].

3. This indicator is in agreement with the calculated figures of other investigators, according to whom the metals input of final societal product in the USSR in 1974 was 42.8 percent greater than in the United States. See [6].

4. Calculated after [9, 10].

5. Obviously the product mix structure of metals output is formed as a compromise between the requirements of the customers and the capabilities of the producers and therefore is an intersectorial factor. But since the capabilities of the metallurgical industry are a stringent limiting factor at any given moment, we shall group metals production structure with metallurgical factors.

6. Calculated after [4, page 403; 19, 20].

7. Calculated after [21, 22].

8. Calculated after [23, 24, 25, 26].

COPYRIGHT: Izdatel'stvo "Nauka", "Izvestiya AN SSSR, seriya ekonomicheskaya", 1981

3024
CSO: 1842/134

LASER TREATMENT OF METALS

Moscow MOSKOVSKAYA PRAVDA in Russian 25 Jul 81 p 3

[Article: "The Beam Which Has Subjugated Metal"]

> [Text] Monday, 20 July. Laser heat treatment, a process utilized at the Plant imeni Likhachev, gives high strength to machinery parts. This process has undergone a series of bench tests.

It is an effect with which we have been acquainted since childhood. Just like a sunbeam, the beam leaps from mirror to mirror, picking up strength in the process. An entire set of spherical mirrors binds a pencil of light into a single powerful beam. Repeatedly reflected, it takes on the shape of a sharp point aimed precisely at the target. The needle of light directed at the metal subjugates it according to any prescribed program: it can cut steel sheets, solidly weld parts together, and can even make metal stronger and harder.

The pace of practical adoption of scientific ideas is speeding up. It was not so long ago that a report on lasers could be obtained only in an institute laboratory. The laser beam, which knows no obstacles, has now blazed a path to industrial production. It is true that it is a bit premature to state that a laser unit is a common sight at an industrial plant, for it is one thing to obtain a beam of the prescribed power under laboratory conditions, while it is a quite different thing to incorporate such a unit into the overall industrial process, to create a production program for the laser, to teach it an industrial trade.

The sign on the door -- "Laboratory" -- is a customary sight at a factory. But its full designation is unique at an industrial enterprise -- a laser laboratory. Test benches, complex test equipment, and finally, the lasers themselves: the layout in this laboratory is akin to that which is created for scientists at research institutes. And there are few differences between them. It is true that the specialists here are less interested in theoretical research. Work is more of an "applied" nature. Each new project has been specifically ordered. This is the principle of the scientific activities conducted at the laser laboratory established at the Moscow Automotive Plant imeni I. A. Likhachev. It has become the base laboratory for the Scientific Research Center on Industrial Lasers of the USSR Academy of Sciences. This firm bond between science and production is already producing impressive results.

Driveshaft parts are loaded into the chamber of an automatic unit. Even people who have little acquaintance with mechanical things know that this is an important assembly in the construction of a modern car or truck. Its strength and operational reliability determine a vehicle's service life and highway safety. And all this is determined in large measure by the quality of welding of the shaft. Let us observe this operation. We see neither the customary welder's sparks or tightly-focused torch flame. The operator switches on the unit, and the assemblies are quickly and surely joined into a single structure. How surely? Tests provided a precise answer. A driveshaft manufactured with the aid of argon-arc welding will last approximately 100,000 kilometers. A laser beam makes this structure much stronger -- its service life is tripled. Such a driveshaft is capable of going 300,000 kilometers without a major overhaul. A laser was added to the welding operations at the Moscow Propeller Shaft Plant, one of the subdivisions of the ZIL Production Association. The laser beam has proven to be a dependable assistant to the automotive workers. First of all, it has given a guarantee of product quality -- the product lasts longer, the processing is a cleaner operation, and metal deformation is reduced to a minimum. In addition, light has also become a rather economical ally of the production people. It saves work time, performing an operation in seconds.

A long-range scientific program. Such plans bind the people at the ZIL Plant with scientists at Moscow State University, Moscow Higher Technical School imeni Bauman, and other scientific research centers. Results obtained by the laser laboratory have shown what can be attained by an alliance with science. Employment of lasers has opened the way for fundamentally new, low-waste technology. This category includes the laser "hardening" technique now employed at the ZIL Plant.

A powerful light beam heats up the target area of a machine part. The hot metal is cooled just as quickly. As a result the machine part acquires high strength and durability. Laser heat treatment makes it possible to strengthen and harden walls between combustion chambers. At the present time this part of a cylinder head wears out fairly rapidly. The high temperatures and aggressive environment in which it operates reduce the service life of the entire structure -- it must be replaced after 150,000 kilometers. But now the laser has been enlisted to harden this assembly. It has proven capable of replacing special furnaces, and it operates at a rate furnaces cannot match. The result of hardening by light beam has exceeded all expectations -- the durability of this engine part has doubled. Now the people at the automotive plant are working together with scientists at Moscow State University on applying this method of treatment to cylinder liners. This research is still in progress; however, just as in many modern scientific endeavors, the principal results are known in advance. They include considerable financial savings.

3024
CSO: 1842/146

SPECIALIZATION URGED IN MAKING SPARE PARTS FOR METALLURGICAL MACHINERY

Kiev RABOCHAYA GAZETA in Russian 21 May 81 p 2

[Article by L. Samoylenko (Zhdanov): "Not Sealed and Guarded"]

> [Text] Specialization of spare-parts production for metallurgical enterprises is a realistic way to cut idle time due to repairs.

When a blast furnace has worked out its time, worn mechanisms and equipment are replaced by new ones. But does the enterprise always have at its disposal the required amount of spare parts?

The answer, not sealed and guarded, is that the reserve of parts is, as a rule, meager. This is one of the reasons that plant managers go more willingly for the erection of production capacity than for reconstruction. For a complete brand-new set of steelmaking equipment comes with a new department. When reconstruction is to be performed, many difficulties arise: it has to be "squeezed" into the existing production facility, which itself must fabricate missing components with its own hands. It is bothersome, but...it is profitable. Rebuilding saves enormous sums.

It is precisely this which has been adopted for many branches of the national economy during the 11th Five-Year Plan. Updating has been planned also for many of the republic's metallurgical plants. However, in setting a task for improving the quality, increasing the quantity and improving the melting of pig iron and steel, one must be concerned in good time about the repair of the equipment.

The industry's demand for spare parts is to a great extent (91 percent) covered by the delivery of products of the repair-production facilities of metallurgical enterprises. The machinebuilders produce a small share (about 2.4 percent). From this comes the conclusion--the reconstruction of open-hearth furnaces, blast furnaces and rolling mills is in the hands of the metallurgical workers themselves. For these purposes, UkSSR Minchermet [Ministry of Ferrous Metallurgy] each year releases almost a quarter of a million tons of castings and 180,000 tons of metal structure. These amounts are not small. So the industry should have at the start of the five-year plan a precise picture of the rational use thereof.

In order to see the future clearly enough, current practice must be put into good order. Let us take, for example, the Zhdanov Metallurgical Plant imeni Il'ich. The enterprise is old, has built up rich experience and has established a sound repair base--the value of fixed capital of the repair shops is at present more than 35 million rubles. Casting, mechanical-machining, forging, pressworking and boiler-installing shops have been concentrated in the metallurgists' hands. Let us compare: identical production facilities of the Zhdanovtyazhmash Association are right alongside. And although here these things are basic, they still are inferior to those of the Il'ichers (for whom they are not basic!) in all categories. Judge for yourself, the repair shops produce twice as many castings and 1.5-fold as much metal structure, and their products mix is almost 3 times as great. "Yes, this is a plant within a plant," has been heard frequently from the specialists.

To some extent they are right. The large metallurgical enterprise has a metalworking plant of average production volume. Anything else, as we see it, cannot be allowed. But why, then, having such a high-powered arsenal for restoration, are the metallurgists so far from living in clover? Ever more frequently their repairmen trip up on level ground.

Let's turn again to the figures. In 4 years (1975-1979) the output of the shops, managed by chief mechanical engineer of the Plant imeni Il'ich, fell by 7 million rubles' worth. Perhaps by reducing the "gross" the products mix had improved? No, this did not happen. Or the enterprise did not need spare parts? Again, this was far from being the case. There was much breakage. Each year excessive idle time for all types of repair averaged 1,300-1,400 hours, that is, more than 50 days. In all, during the last five-year plan, 120 planned current repairs were not performed. Seven times they wrote up, "to overhaul," and put it aside. Why? Often there is no procedure for organizing the work, so it is done as unscheduled work, introducing confusion throughout the whole metal-producing chain. This has been mentioned repeatedly at the repairmen's conferences and party meetings. And, it would seem, it is within their powers to overcome a slight muddle.

It is much more difficult to step over one enterprise by way of troubles that are firmly established in the repair experience of the whole industry. What are we talking about? Each metallurgical enterprise, as mentioned above, provides itself from head to foot with spare parts. This is done also at the Plant imeni Il'ich. And, of course, there is no stinting when consuming metal for themselves, and with all their might they strive to build up the repair base, although the yield of some lines is low. They make equipment for their own needs, and, as they say, for tranquillity. And how does the Azovstal' plant behave in this case? Exactly the same. And the repair bases here are the same. It happens that spare parts are lying in their warehouse, but at the neighboring enterprise they are breaking their heads about where to get them. Deadlines for rebuilding are missed, and so, rolling up their sleeves, Azovstal' personnel hurriedly manufacture that which is lying unused at an allied plant.

"Each year as many articles go into the overhaul of blooming mills in the country as are needed for seven new reduction mills. Parts are produced not serially but in an 'individual' procedure, that is, on demand. But each time the repairers still do not have enough of something. This happens because cooperation between metallurgical enterprises in the industry is poorly developed," says chief of the Economics Section of the Zhdanov Branch of Ukrgipromez [Ukrainian State Institute for the Design of Metallurgical Plants] V. Vasil'yev.

"How should it be improved?"

"A coordinating organ must be established. It is certain that a fruitful exchange of spare parts will more than repay for such a step."

"And what is to be done with the production itself of the parts?"

"In leaving the structure of their production unchanged, it would be easy to get drowned in the movements from plant to plant of the most diverse components and equipment. The principle, 'Everyone makes everything,' is not appropriate. Such a paper blizzard would break out that soon every exchange would simply be ineffective. It would seem that the way out is the emergence of a concentration of output by type of spare parts and replacement equipment."

And this is actually so. Let us suppose that rollers are needed today to rebuild a mill. The order arrives at the repair services. The rolls are made again in an individual procedure, for in-house needs. But the same needs exist at a neighboring enterprise. Why aren't these rolls produced serially at the shop that is better adapted for doing so? And supply them in accordance with subcontracting arrangements and obtain needed equipment or spare parts from other plants. The advantages are obvious. Right away inflated products lists would be cut, and this would be a direct path to an increase in the yield of shops that are working for reconstruction.

It is difficult to take exception, but in the industry it is considered that it would be better to transfer basic functions for producing spare parts to the machinebuilding plants, increasing their share of deliveries to 25 percent by the end of the 11th Five-Year Plan. Such an approach is hardly feasible, for the pace (from 2.4 percent to 25 percent) is not realistic. Experience suggests that a substantial benefit can be obtained precisely by concentrating the serial production of various parts by type at specialized repair shops of metallurgical enterprises.

But an amalgamation of cooperative arrangements of two or three plants still does not solve the problem. In the opinion of Ukrgipromez specialists, it would be desirable to establish a regional clustered scheme. Each association (at Donetsk and Dnepropetrovsk, let's assume) should have at its disposal designers, industrial services and planning units. Metallurgical, byproduct-coke, tube, metalware, refractory and machinebuilding enterprises for the republic's ferrous metallurgy would join the association.

The final result of this work would be the rhythmic output of spare parts, building up the output thereof without additional capital investment or increase in repairer manpower. In the long term this would enable conversion to production by components--a progressive method for restoring enterprises, which involves, in its turn, a considerable reduction in the idle time of operating units and an increase in the output of cast iron and steel and rolled metal.

11409
CSO: 1842/125

NORM SETTING OF INTERNAL WORKING CAPITAL AT MINING ENTERPRISES

Moscow FINANSY SSSR in Russian No 4, Apr 81 pp 29-31

/Article by A. S. Sokolov: "Problems of Improving the Norm Setting of Internal Working Capital at Mining Enterprises"/

/Text/ The speeding up of the turnover rate of working capital is called upon to promote the increase of the output of products, the reduction of production costs and the increase of the profitability and the profit. However, as the accounting data of individual enterprises and ministries show, given the existing system of the norm setting of internal working capital, which is spent on mine development work and stripping, this is not happening. The standard for stripping covers the expenditures on the extraction and removal of the gangue from the open pits, but since these expenditures have been increasing for decades, the previously invested capital is not being recovered, that is, the standard is assuming the nature of long-term investments of internal capital. Thus, on 1 January 1981 for the USSR Ministry of Nonferrous Metallurgy and the USSR Ministry of Ferrous Metallurgy it came to more than 2 billion rubles. The situation is similar in the USSR Ministry of the Construction Materials Industry, the USSR Ministry of the Coal Industry and others.

An increase of the balances of unrepaid mine development work and stripping, which are carried out at the expense of internal working capital, has been observed in recent years. For example, at the mining enterprises of the USSR Ministry of Ferrous Metallurgy the actual balances of the expenditures on these operations, which have been attributed to the expenses of future years, were estimated on 1 January 1970 to be 480 million rubles, while by the end of 1979 they were estimated to be 1,102,000,000 rubles. The time has come to look into the causes of the rapid increase of the standard of internal working capital being allocated for mine development work and stripping, to outline ways to recover the capital invested in unrepaid expenditures, as well as to stabilize and delimit the sources for the performance of stripping.

In accordance with prevailing procedure a portion of the expenditures on mine development work and stripping is written off to the production cost of the mined ore according to the planned repayment factor, while the remainder is attributed to the expenses of future years. A standard of internal working capital is envisaged for this purpose. Moreover, the planned repayment factor is made more precise annually with allowance made for the balances of industrial reserves of minerals in the planned contours of the open pit, as well as the mine development work which has not been paid off. Thus, at the iron ore enterprises of the USSR Ministry of Ferrous Metallurgy alone from 1970 to 1979 stripping worth 3.1 billion rubles was performed, 2.57 billion rubles were written off to the production cost of the iron ore, while the standard of the internal working capital was increased by the remainder. The production of ore during this period increased by 49 percent, while the balances of the unrepaid expenditures on stripping increased by 163 percent. Consequently, the demand for capital to a considerable extent is leading the growth rate of the production of iron ore.

This attests that the procedure of writing off the expenditures on mine development work and stripping is not conducive to the timely and complete attribution of the actual costs to the production cost of the ore. One of the main causes of such an economically incorrect reflection of expenditures is the fact that the further prospecting for minerals and the expansion of the open pits by placing the next sections into operation are carried out during the working. The latter begin operating before the exhaustion of the reserves of ores of the preceding sections, and the working of the open pits is carried out in the planned indicators which are common for the two sections. When placing each section into operation the repayment factor of the stripping is averaged out, the term of working is lengthened, the expenditures on the stripping of the preceding sections are not completely assigned to the production cost of the ore and the investments of internal working capital are increased.

For example, the construction of the first section of the open pit of the Inguletskiy Mining and Concentration Combine, the term of operation of which was set according to the plan at 25 years, with a capacity of 18 million tons of crude ore a year, was completed in 1965. The planned overburden ratio for the entire ore body of the open pit was determined at 0.164 m^3 per ton. In 1967 they began to construct its second section, and the rated capacity increased to 30 million tons. The average overburden ratio according to the plan of the second section was equal to 0.84 m^3 per ton, while the average for the two was determined to be 0.34 m^3. In 1973 they began the third section, which provides for an increase of the capacity by 6.4 million tons of ore a year. The average ratio for this section was only 0.117 m^3 per ton, while with its placement into operation it was determined to be in the amount of 0.31-0.32 m^3 per ton. Subsequently, with an amount of stripping of 11 million m^3 a year and a production of crude ore in the planned amount, that is, 36 million tons, the current ratio is being maintained at the same level.

With the placement of the third section of the mine into operation the rated capacity was revised and the term of operation was extended to 1998. Before the end of the working of the open pit it is outlined by the plan to perform in approximately 6 years 58.9 million m^3 of stripping and to complete the stripping of the rock in 1983. Then it is envisaged to begin the reduction of the balances of unrepaid stripping, that is, to decrease the standard over 14 years. At the same time by 1998 the unrepaid balances will amount to more than 10 million m^3, which is evident from the following data:

Planned repayment factor	0.135 m^3/ton
Annual planned productivity	36 million tons
Repayment of expenditures during the year (planned)	4.9 million m^3
Repayment of expenditures during remaining 19 years	93.1 million m^3
Repaid prior to 1979	47.3 million m^3

/Continued on following page/

Total that will be repaid	140.4 million m^3
Amount of stripping, which is necessary for complete removal of crude ore	152 million m^3
Unrepaid work remaining after exhaustion of the open pit	12 million m^3

The data attest that either in the plan the term of operation of the open pit was imprecisely specified, or the repayment factor does not ensure the complete repayment of the expenditures on the stripping before the exhaustion of this open pit. In 15 years stripping worth 125.2 million rubles is performed, while only 50.3 million rubles are attributed to the production cost; the remaining expenditures are attributed to expenses of future years.

A plan of the further development of the mine, which proposes an increase of the capacity to 43 million tons of crude ore a year, is now being drawn up. For this section of the open pit it will be necessary to perform several times more stripping than for the section in operation. Thus, the standard of internal working capital will also increase further, while the repayment stipulated by the plan will be put off for a long time.

The annual increase of the balances of unrepaid stripping is a consequence of writing off the expenditures to the production cost according to a repayment factor which is less than the current overburden ratio. For example, at the Inguletskiy Mining and Concentration Combine the norm of repayment has been set in the amount of 0.17 m^3 per ton of crude ore, while the actual amounts for stripping were twofold greater. At the Yuzhnyy Mining and Concentration Combine the average amount of the current ratio (the ratio of the performed stripping to the extracted amount of ore) for 24 years of operation was equal to 0.38 m^3 per ton. Moreover, since 1964 this ratio has fluctuated from 0.36 m^3 to 0.44 m^3 and is twofold greater than the repayment factor. With respect to all the iron ore enterprises of the Ukrainian SSR Ministry of Ferrous Metallurgy in the past 9 years 0.64 m^3 of stripping was performed on the average for extracting 1 ton of crude ore, while 0.48 m^3 was assigned to the production cost of a ton of ore, that is, 25 percent of its amount was performed at the expense of internal working capital.

Mine development work is divided into capital and operating work in conformity with the instructions on the planning, accounting and calculation of its cost. The work on the stripping of the deposits and the construction of structures for their working is assigned to the former, if the extraction of reserves of ore continues for more than 4 years. They are the stripping of the explored deposits, the construction of access roads, hoisting structures, drainage, slot trenches and so on. They are performed at the expense of allocations for capital construction and are financed by the All-Union Bank for Financing Capital Investments.

At operating enterprises the capital mining work and the operational mine development work are performed, as a rule, by the same workers and are served by the same equipment and vehicles. In such cases a significant portion of the expenses cannot be assigned to the named operations with respect to the direct purpose. In this connection the capital mining work performed by the workers of the enterprise is planned and taken into account along with the operational mine development work and is regarded as work which is performed by the intercontract method.

The operational mine development work is planned and taken into account with respect to the main activity of mining enterprises and is performed at the expense of the production cost. However, as a result of the fact that the capital investments for stripping are allocated only at the start of the construction of the open pit, while for the subsequent sections their amount is reduced or they are not envisaged at all, since the procedure of financing these expenditures makes it possible to make them at the expense of the internal working capital, an increase of the expenditures not written off to the production cost occurs.

In the total expenditures the capital mining work performed at the expense of the capital investments makes up a negligible portion. Thus, at the Inguletskiy Mining and Concentration Combine 12 million rubles of this work were performed (the total amount of stripping was 114 million rubles), while at the Yuzhnyy Mining and Concentration Combine--40 million rubles (244 million rubles). For all the open pits of iron ore enterprises from 1970 to 1978 capital mining work worth 209 million rubles was performed, while stripping worth 2,747,000,000 rubles was performed at the expense of the operating capital.

Capital mining stripping differs from stripping of an operational nature only by the source of financing. Therefore, when constructing the sections the conditions exist for shifting around three sources of assets for the expenditures on stripping: the allocations for capital construction, the production cost and the working capital. The data cited by us on the capital investments in capital mining work attest that open pits are expanded mainly at the expense of working capital, and this leads to the decrease of the value of the fixed capital of the mining enterprise. This is advantageous for design organizations, since the conditions are created for paying bonuses to workers for saving on the estimated cost of the open pit.

Thus, during the use of the prevailing system of the financing of mine development work and stripping the production cost of the ore has been clearly understated, since it does not include all the expenditures connected with its extraction, the investments of internal working capital in the unrepaid portion of the mine development work are increasing annually and, hence, it is impossible to set specific dates of the repayment of the previously spent capital.

Having analyzed the causes of the increase of the standard of internal working capital for mine development work and stripping, we offer possible versions of the recovery of the working capital. The most feasible means for ensuring the constant and stable return of internal working capital is the addition of the balances of the expenditures on mine development work and stripping, which have not been repaid by 1 January 1981, to the value of the fixed capital of mining enterprises and the amortization of this capital until the complete exhaustion of the reserves of minerals, but not for more than 25 years, that is, at a rate of amortization of 4 percent.

There are also other versions of the writing off of unrepaid mine development work, in particular by the establishment of differentiated stage-by-stage repayment factors, which are determined on the basis of the dates of the exhaustion of the deposits by sections. But in this case it is impossible to solve the question of writing off the accrued expenses, while the specified differentiated factors can be attributed only to the operating sections or the sections being newly put into operation.

Some economists propose to write off the accumulated reserves through stage-by-stage factors, which are established for 5-year periods, up to the complete exhaustion of the deposits. The proposal merits attention, but it is necessary to approach differentially the repayment factor, taking into account the specific estimates for each open pit, the period of the working of which is running out, as well as for the open pit being developed and newly placed into operation.

Moreover, the establishment of fixed stage-by-stage repayment factors in the case of the nonfulfillment of the plan of stripping during individual periods, especially by the time of the covering of all the previously made expenditures on mine development work, and in the case of a negligible amount of planned stripping, can lead to the excessive repayment of the expenditures on stripping, that is, the assignment of expenditures not yet made to the production cost of the ore. There are also proposals on the one-time complete writing off of the standard for mine development work and stripping, which have not been repaid by 1 January 1981, and on the one-time reduction of the authorized capital.

In our opinion, the method of recovering the capital previously invested in the unrepaid portion of the mine development work and stripping by adding it to the value of the fixed capital is more acceptable, since this will make it possible to ensure its constant and stable recovery. The repayment of the previously made expenditures by the use of an independent repayment factor, which is established up to the exhaustion of the open pit, but for not more than 25 years, is also possible.

For determining the real production cost of mining enterprises it would make sense to assign the expenditures of each year on mine development work and stripping as of 1 January 1981 entirely to the production cost and, hence, not to provide for standards of internal working capital for these purposes. Such a proposal arouses doubt among some economists who cite the following arguments. The geological mining conditions at mining enterprises are notable for great diversity and sharp fluctuations of the amounts of mine development work and stripping during different periods of the working of deposits. Therefore the complete assignment of the expenditures on these operations, which are performed during the year, to the production cost of the ore being mined will lead to sharp fluctuations of its production cost during different periods of the working and to the aspiration of enterprises to reduce the amounts of mine development work and stripping. This will worsen their readiness for the further production of ore.

The analysis of the performance of mine development work and stripping shows that over many years there was no significant fluctuation in the amounts of production of iron ore, the performance of stripping, its repayment and, consequently, in the production cost of the ore, with the expection of the time connected with the construction and development of subsequent sections. In the case of the construction of new sections the amount of stripping during the first years increases appreciably, but the expansion is carried out at the expense of the working capital or by means of negligible amounts of capital investments. Such a procedure does not conform to the correct breakdown of the planned stripping into mining capital and operational stripping.

In this connection we consider it necessary to allocate capital investments for stripping when expanding the capacities of open pits in amounts which ensure that the open pit will achieve the rated capacity or the stable production of ore in 3 years. As to the fluctuation of the production of ore by months during the year, it is possible to solve this problem, having established fixed factors of the repayment of the expenditures, while having assigned the overfulfillment of the plan on mine development work and stripping to the production cost of the following year. There are also proposals on the norm setting of the expenditures on mine development work and stripping in the same way as for unfinished production.

However, from what was stated above it is evident that the mine development and stripping costs do not meet any of the requirements of the determination of the norm of working capital for unfinished production. Taking into account that the state of the internal working capital influences the results of the activity of enterprises, the output and marketing of products, while the acceleration of their turnover rate promotes a decrease of their production cost and an increase of the profitability, we consider it expedient to revise the system of the norm setting of internal working capital for mine development work and stripping. This is necessary so that the recovery of the internal working capital invested in preceding years in the unrepaid expenditures on these operations would be ensured, as well as for determining the real cost of the output of mining enterprises. Then the effectiveness of the monitoring by financial organs of the standard of internal working capital, the production cost of the ore, the expenditures on the development of the mining industry and the profitability of mining enterprises will increase.

COPYRIGHT: "Finansy SSSR", 1981

7807
CSO: 1842/124

CHANGES IN SPECIFIC POWER OF AN ELECTRON BEAM DURING FORMATION OF A HOLE

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, Mar-Apr 81
(manuscript received 17 Jul 79) pp 34-38

KALACHEV, V. V. and PETROV, A. I., Moscow

[Abstract] An electron beam impinging on a solid surface loses energy due to the heating and melting of the material. The amount of thermal energy may be calculated from heat transfer equations. To a first approximation, the thermophysical properties of the materials may be considered as constants and not a function of temperature. The pertinent equations are developed which specifically express the relationships between the parameters of the electron beam and the thermophysical properties of the material upon which the beam is incident. The calculated values for the penetration rate of the beam-generated hole are rather close to the experimental values. The penetration rates decrease in the order Al > Ti > Cu > Ni > Fe, and range from 4 m/sec for 0.3-mm-thick Al to around 1 m/sec for 3-mm-thick Fe. The calculations are valid for thicknesses ranging to 6.0 mm, and are useful for calculating the optimum regimes for preparing perforated manufactured goods. Figures 3; references 4: 3 Russian, 1 Western.
[112-12027]

APPLYING ELECTRIC-SPARK ALLOYING TO CHANGE OPTICAL PROPERTIES OF METAL SURFACES

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, Mar-Apr 81
(manuscript received 29 Nov 79) pp 28-30

NAZAROV, Yu. F. and ZLATKOVSKIY, V. B., Khar'kov

[Abstract] Electric spark alloying was used to alter the coefficient of adsorption A_s and the solar reflectivity ϵ of two titanium alloys (VT6 and VT 14) and two aluminum alloys (AMg6 and AMg3). Eight different anode materials were examined: molybdenum, tungsten, nickel, niobium, zirconium, lead, magnesium, and graphite. The spark alloying process increased the values of both A_s and ε. After treatment, these values for the titanium alloys ranged from 0.68 to 0.72 and 0.35 to 0.40, respectively; the same parameters for the aluminum alloys ranged from 0.50 to

0.56 and 0.20 to 0.22 respectively. The minimum value of A_s was obtained for the combination zirconium anode + titanium alloy; the maximum, graphite anode + aluminum alloy. The minimum value for ε was observed for the combination molybdenum anode + either alloy; the maximum, for magnesium anode + VT6 titanium alloy. These variations were caused by submicroscopic changes in the surface evenness and homogeneity. Figures 4; references 4: all Russian.
[112-12027]

KINETICS OF DEFORMATION AND DESTRUCTION OF SOME ELECTROPLATED COATINGS BY FRICTION

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, Mar-Apr 81 pp 25-28

RAPOPORT, L. S., Kishinev

[Abstract] Deformation and destruction by friction is localized in thin surface layers and leads to the formation of a honeycomb fragmented structure. The effect of loading, in the range of 1.7 to 100 N, on the destruction of iron and chromium electroplated surfaces was evaluated experimentally at a temperature $\theta = 0.17$. For the entire range of loadings, the coefficient of friction (f) for the iron was less than that for the chromium; (f) also decreased with increasing loading. When the ratio of P (the specific loading) divided by H_μ was plotted against (f), the curve could be divided into three distinct regions, reflecting three types of material behavior: brittle and ductile fracturing, and also a region transitional between the two. The characteristic relationships for the change in (f) indicate that processes resulting in the deformation and destruction of plated surfaces may be rather accurately described by the general kinetics expressions and the thermofluctuation equation for the durability of materials

$$\tau = \tau_0 \left[\frac{U_0 - \gamma_\sigma}{KT}\right]$$

where τ_0, U_0, and γ are constants; σ is the pressure; and T is the temperature. Figures 2; references 14: 12 Russian, 2 Western.
[112-12027]

UDC: 621.923.4:621.922:621.921.34:666.233

PROBLEM OF FORCES IN MICROCUTTING OF HEAT RESISTANT AND TITANIUM ALLOYS

Kiev SVERKHTVERDYYE MATERIALY in Russian No 1 (10), Jan-Feb 81
(manuscript received 7 Apr 80) pp 48-50

SAGARDA, A. A., POLUPAN, B. I., MATSKEVICH, V. P. and GRIGOROVA, L. S.,
Institute of Superhard Materials, Ukrainian Academy of Sciences

[Abstract] A study is made of the influence of the speed of cutting on the forces arising during microcutting of nickel heat resistant and titanium alloys types VZhL, VT3-1 and also type 1Kh18N9T stainless steel. The microcutting system used models of the work of a single abrasive grain during grinding at the periphery of a disk. The maximum frequency of the process was never over one-fifth the natural oscillating frequency of the dynamometer. Experiments were conducted on a model 3G71 grinding machine, with profiles measured at 5 to 8 cross sections to study the nature of the scratch formed and determine the volume of metal carried away in the chip. The experiments show that in all cases as the speed of the indentor increased, the cutting force components increased, most greatly in the range from 0.1 to 10 m/sec. The results of the studies agree with data obtained in studies of changes in the mechanical parameters of structural materials under the influence of rapid loading. The inertia of the measurement system must be considered in recording the component forces involved in microcutting. When studying cutting speeds exceeding 25 to 30 m/sec, one must consider not only the change in deformation of the fibers of the material of the dynamometer, but also the transmission of an elastic wave through the structure of the dynamometer. Figures 4; references 11: 10 Russian, 1 Western.
[131-6508]

UDC: 620.178.222:620.174.2

POSSIBILITY OF DETERMINING CRACK RESISTANCE CHARACTERISTICS WITH FINAL FORMATION OF A NOTCH BY PRESSING

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 46, No 10, Oct 80
(manuscript received 18 Dec 79) pp 953-954

BELIK, A. V., DOLZHENKOV, F. Ye., NAVROTSKIY, I. V. and GULEVSKIY, A. S.,
Donets Scientific Research Institute of Ferrous Metallurgy

[Abstract] A comparatively simple method is described of determining the characteristics of crack tolerance in specimens with an initiated fatigue crack consisting of a notch formed by pressing. The notch is initially milled in specimens measuring 10 x 10 x 55 mm to a depth of 1.6-1.7 mm with an aperture angle of 45° and a tip radius of 0.25 mm. The notch is then extended to a depth of 0.3-0.4 mm by pressing in a sharp tipped steel wedge. After this operation the radius is 0.03 mm at the tip. Since the increase in thickness of the

specimen due to this pressure operation is very slight, it is not considered in determining the crack tolerance characteristics. This method simplifies the estimation of crack tolerance and expands its capabilities. Figures 3; references 5: all Russian.
[132-6508]

UDC: 666.764.4:620.174

SELECTING CONDITIONS FOR DETERMINING EFFECTIVE SURFACE ENERGY OF FRACTURE OF BRITTLE MATERIALS

Moscow AZVODSKAYA LABORATORIYA in Russian Vol 46, No 10, Oct 80
(manuscript received 13 Mar 80) pp 952-953

BARINOV, S. M., GREVTSEV, S. N. and KRASULIN, Yu. L., Institute of Metallurgy imeni Baykov, USSR Academy of Sciences, Moscow

[Abstract] A study is made of the influence of geometric test conditions on the critical value of notch depth during beam bending tests. The study was conducted on specimens of graphite under 3-point bending conditions with a variable ratio of length to width of the beam. It was found that a decrease in the ratio L/h can decrease the measurement error in spite of limited sensitivity of the force-measurement system. The critical values of relative crack depth at which a transition is made to stable propagation were found to depend little on L/h within limits of 4 to 8. Figures 2; references 5: 3 Russian, 2 Western.
[132-6508]

UDC: 621.923

RESIDUAL STRESS IN HARD ALLOYS OF THE VK GROUP AFTER DIAMOND GRINDING

Kiev SVERKHTVERDYYE MATERIALY in Russian No 2, Mar-Apr 81
(manuscript received 23 Jul 79) pp 61-64

SMAGLENKO, F. P., Institute of Superhard Materials, Ukrainian Academy of Sciences, Kiev

[Abstract] The type I residual stresses were studied in the alloys VK6, VK8, VK15 and VK20. The experiments showed that after sintering there are usually tensile stresses of $5\text{-}10 \cdot 10^2$ MPa, though compressive stresses arise in some cases. The depth of penetration of these stresses is 0.02 to 0.03 mm. The magnitude and nature of the distribution of residual stresses in VK-group alloys is thus determined by the specific sintering conditions, rather than the content of cobalt in the alloy. Grinding of these alloys can produce significant residual stresses down to a depth of 0.01-0.02 mm. The nature of distribution of the stresses in all of the alloys tested after grinding is approximately the same,

compressive stresses at the surface with zero or tensile stresses at depths of over 0.02 mm. Figures 4; references 8 Russian.
[114-6508]

UDC: 621.922.029

SOME PROBLEMS OF DEFORMABILITY OF DIAMOND-CARRYING LAYER OF DISKS DURING SHAPING AND STRAIGHTENING

Kiev SVERKHTVERDYYE MATERIALY in Russian No 2, Mar-Apr 81
(manuscript received 10 Jun 80) pp 28-33

ITSKOVICH, M. S., Institute of Superhard Materials, Ukrainian Academy of Sciences, Kiev

[Abstract] The method of profiling and straightening diamond grinding disks by plastic deformation is one of the most important means of manufacturing complex shaped diamond grinding tools. The plastic properties of the diamond-carrying layer were studied by tests of cylindrical specimens 10 mm in diameter and 20 mm long in uniaxial compression. The ductility of the material was estimated by the maximum relative deformation in compression before the appearance of cracks, the beginning of failure. The plastic properties were also studied during rolling of a threaded profile on disks 50 mm in diameter and 10 mm long, the criterion of ductility in this case being the maximum thread step which could be rolled onto the material without causing fracture of the diamond-bearing layer. It was found that the binder has the greatest influence on the plastic properties of the layer. An effective means of increasing ductility of these layers is the creation of special binders such as various copper, nickel and iron alloys obtained by powder metallurgy and widely used in the manufacture of metal binders. Photomicrographs of diamond-bearing layers before and after compression are presented. Diamond grains were found to cause nonuniformity of distribution of stresses in the matrix. The deformability of the diamond-bearing layer can be regulated over broad limits by selecting the binder and the concentration of grains. A 75% concentration of diamond grains is optimal from the standpoint of ductility of the binder. Figures 5; references 2: both Russian.
[114-6508]

UDC: 620.17:539.4

LIMITING STATE CRITERIA OF CERTAIN STEELS UNDER COMPLEX STRESS CONDITIONS AT ROOM TEMPERATURE AND ELEVATED TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 5, May 81
(manuscript received 4 Dec 80) pp 10-15

KOVAL'CHUK, B. I., Institute of Strength Problems, Ukrainian Academy of Sciences, Kiev

[Abstract] An experimental study is made of the strength of type 10GN2MFA and 15Kh2NMFA steels used in the manufacture of hulls at 20 to 400°C in order to determine the equivalent stress states under biaxial loading. Studies were performed on tubular specimens with inside diameter 25 mm and wall thickness 0.5 mm. The specimens were cut from massive forgings, and heat treated as follows: 10GN2MFA steel--hardening twice from 920 and 860°C with quenching in water, tempering twice at 620 and 650°C; 15Kh2NMFA steel--hardening twice from 920 and 900°C with quenching in oil and water, then tempering once at 650°C. The specimens were loaded with axial force and internal pressure created by water and superheated steam, with heat supplied by heating elements within the specimens. The limiting yield surface of the 10GN2MFA steel is satisfactorily described by the Guber-Mises condition. The experimental points for 15Kh2NMFA steel usually occupy an intermediate position between this theorem and the Coulomb-Trask condition. For most structural materials the onset of creep agrees better with the Guber-Mises theorem, while fracture agrees better with the Coulomb-Trask theorem. An attempt is made to explain this behavior of the materials by analysis of the mechanism of plastic deformation of a polycrystalline aggregate. Figures 4; references 7: all Russian.
[126-6508]

UDC 669.018.19:669.245'71

STRUCTURAL ALLOY BASED ON INTERMETALLIDE Ni_3Al

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 81 pp 23-26

PORTNOY, K. I., BUNTUSHKIN, V. P. and MELIMEVKER, O. D., All-Union Scientific Research Institute of Aviation Materials

[Abstract] An investigation is made of the properties of a cast alloy based on intermetallide Ni_3Al doped with chromium, titanium, tungsten and other elements. The content of impurities of sulfur, phosphorus, lead, bismuth and antimony did not exceed 0.003% each. The structure of the cast alloy is heterogeneous with fine equiaxial grain, without pronounced dendritic liquation. Dispersed particles of high-melting compounds are segregated along the grain boundaries and in the body of the grains. The average size of the particles is 0.3-1.5 μm. The

principal dopants--chromium, tungsten and titanium--are mostly dissolved in the matrix, and only a small portion is bound in the form of finely dispersed particles of high-melting compounds. The alloy has good casting properties, satisfactory flowability and is not inclined to crack, and the linear and volumetric shrinkage are close to these properties in high-temperature nickel alloys. Mechanical properties remain practically unchanged after prolonged annealing in an oxidative medium. The yield point and ultimate tensile strength at 900°C are somewhat higher than at room temperature, and the ductile properties are somewhat lower. At temperatures of 1000°C and higher, there is a noticeable reduction in strength characteristics, although the alloy remains fairly strong up to temperatures of 1200°C. The alloy based on Ni_3Al is superior to specimens of high-strength nickel-base alloy in withstanding thermal shock. Figures 4; references 4: all Russian.
[133-6610]

UDC 699.017.004.69

NEW MATERIALS AND TECHNICAL PROGRESS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, Jun 81 pp 3-8

SHALIN, R. Ye., All-Union Scientific Research Institute of Aviation Materials

[Abstract] Recent advances in metal science and physicochemical research have resulted in the development of new light, high-strength materials with improved modulus of elasticity and stiffness coefficient, reduced inclination to cracking and a wider range of applications than conventional structural materials. The author shows how these new materials, and in particular heat-resistant nickel, titanium, aluminum and other alloys and composites, are affecting technical progress in machine building. The most important problems in developing new alloys for aerospace technology are discussed, and recommendations are made on using the new materials in other sectors of the national economy. Examples are given of considerable savings in material and labor inputs in production that can be realized from introducing new corrosion-resistant, heat-resistant and technological coatings.
[133-6610]

UDC: 548.53:539.219

INFLUENCE OF CRITICAL STAGE OF POLYGONIZATION ON DUCTILITY CHARACTERISTICS OF TUNGSTEN IN HIGH TEMPERATURE MECHANICAL TESTS

Kiev PROBLEMY PROCHNOSTI in Russian No 5, May 81
(manuscript received 4 Aug 80) pp 82-88

KRAVCHENKO, V. S. and KHARCHENKO, V. K., Institute of Strength Problems, Ukrainian Academy of Sciences; Institute of Metal Physics, Ukrainian Academy of Sciences, Kiev

[Abstract] A study is made of the mechanism of embrittlement of V-PM tungsten in the high temperature area under short-term static loading. Photomicrographs reveal that there is a characteristic type of fracture for all specimens with reduced ductility, combining broad areas of pit fracture with clearly defined bands of viscous prefracture. It is found that by the moment when dislocation sources begin to operate, the elastic stress may be so great that their relaxation occurs by practically instantaneous failure of the material (cracking). It is this process which is responsible for embrittlement of the material as the critical stage of polygonization is passed. This process causes great deterioration in the mechanical properties of the material.
[126-6508]

CSO: 1842

- END -

END OF FICHE

DATE FILMED

17 Sept 1981